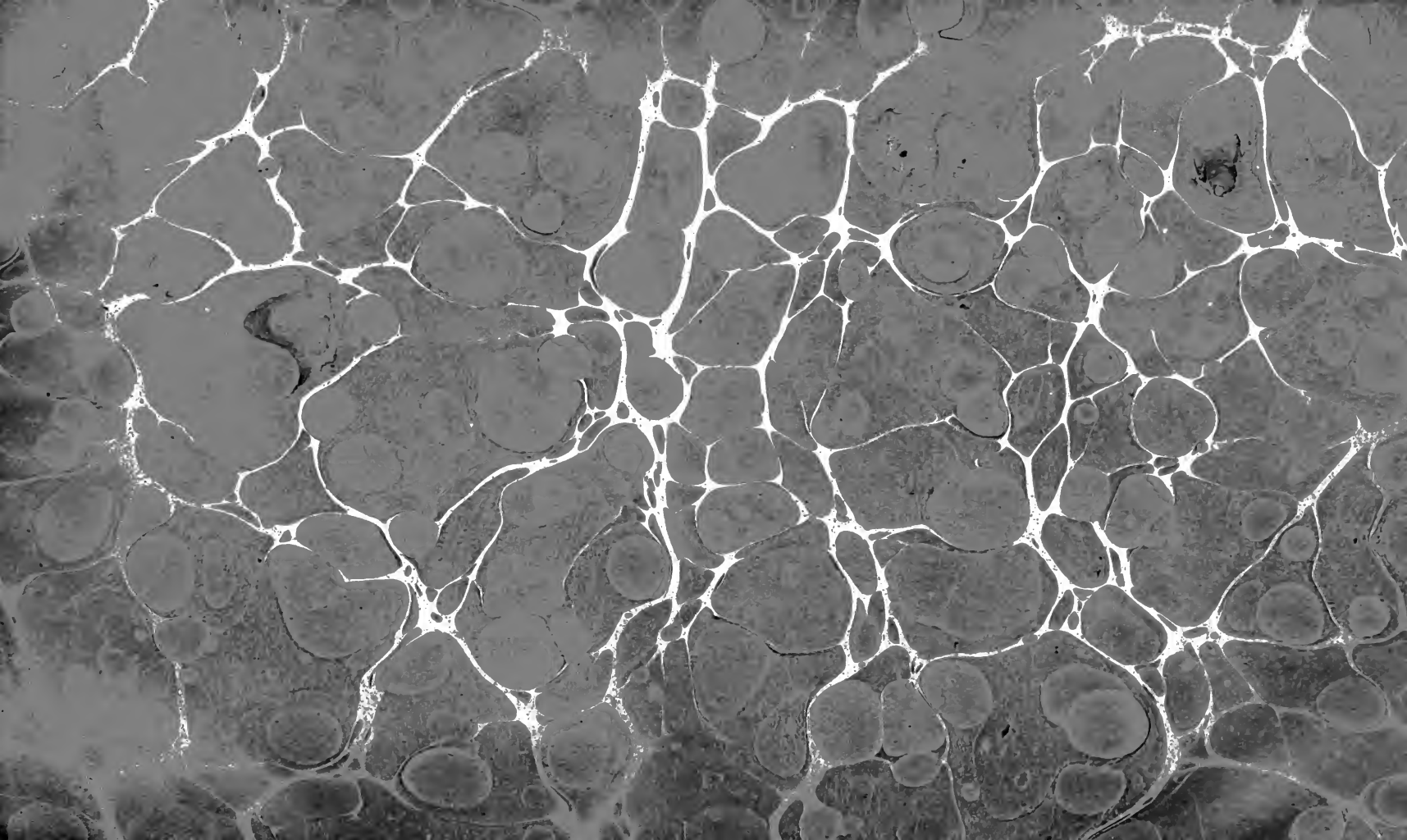


Ohio State Academy of Science

SPECIAL PAPERS No. 3.

THE PREGLACIAL DRAINAGE OF OHIO

Comprising the Results of Researches made by Members of the Academy of Science, by the Aid of the McMillin Research Fund

Published by the Academy of Science
with the Emerson McMillin Research Fund.

DECEMBER, 1900

Ohio State Academy of Science.

SPECIAL PAPERS NO. 3.

THE PREGLACIAL DRAINAGE OF OHIO

Comprising the Results of Researches made by Members of the Academy of Science, by the aid of the McMillin Research Fund.

PUBLISHED BY THE ACADEMY OF SCIENCE
WITH THE EMERSON E. McMILLIN RESEARCH FUND.

December, 1900.

PRESS OF FRED. J. HEER, COLUMBUS, OHIO.

PREFACE.

AT the 1898 winter meeting of the Ohio State Academy of Science, Mr. Emerson E. McMillin, already a life member, through Professor W. R. Lazenby, tendered the Academy the sum of $250.00 to be expended by the trustees in furthering original scientific researches in Ohio. The donor placed no restrictions upon the use of this fund except to express a desire that, so far as possible, it be used in aiding those who are competent and willing to give their time, but unable to contribute their expenses while employed in their researches; thus giving aid to such independent workers as lacked the necessary financial resources. Among the grants made by the trustees during 1899, from this fund, were $50.00 each to Professors Tight and Bownocker, and $10.00 to J. H. Todd, M. D., for the purpose of aiding them in studying the Preglacial Drainage of certain portions of Ohio. From this fund for 1900, Mr. Gerard Fowke was granted the sum of $25.00, for a similar purpose. The results from the work prosecuted under these grants are herewith transmitted as No. 3 of the Series of Special Papers. Mr. Fowke has kindly consented to prepare an introduction, giving a short review of work previously done along this line of research in Ohio. The map facing preface illustrating the preglacial drainage of the entire State, so far as it has been worked out, has been prepared by Professor Tight.

The expense of publication has also been taken from Mr. McMillin's research fund, which he has been kind enough to continue for 1900.

Professor Raymond Osburn was granted $50.00 in 1899 to aid in the study of the fishes of the State, and a similar sum was granted him in 1900. The results of Professor Osburn's researches are being prepared for publication and will constitute No. 4, of this series, and will be issued early in 1901.

F. M. WEBSTER, *Chairman*,
H. C. BEARDSLEE,
JOHN H. SCHAFFNER,
Trustees Ohio State Academy of Science.

INTRODUCTION.

FOR many years the abandoned water courses in Ohio have perplexed geologists. Most of them are attributed to streams in the immediate vicinity. Some, however, are in such situation that no existing river or creek could produce them unless very great alterations of level should take place. Others interlock in a manner which would require exceedingly rapid and violent changes in any stream now found within many miles, if their origin is to be thus explained. For example, each one of four ancient valleys located within the limits of Hamilton county, namely, back of Cincinnati, along Mill creek, at North Bend, and across the northern and western ends of the county, is accounted for by assuming that "the Miami river must have once followed this course." But it would be impossible for the Miami to excavate them, because all have a greater depth than the bed of the Ohio river; and the latter could never have been deeper than it is now, for below the mouth of Mill creek there is rock bottom. Besides, the Miami could form them only by accomplishing the improbable feat of eroding a deep channel and then, without any discoverable reason, deserting this course and carving a new one for itself through the bordering hills.

The same difficulty is encountered when the attempt is made to connect former and recent stream beds in various other parts of the State.

The great variation in width of different portions of the Ohio valley has also awaited explanation. A traveler from Pittsburg to Evansville will find the hills on either side alternately approaching the water and receding from it. In some parts they are so steep and come so near together, as to form a veritable gorge; again, level or terraced bottom lands a mile or even more in width intervene between the shores and the high lands. Moreover, there is no system or regularity about these changes. Sometimes there may be observed a gradual increase in width,

very slight it is true but still perceptible, the hills presenting gentle slopes and smooth, rounded outlines; then the valley begins to narrow, the hills are more sharply outlined, and presently the stream is running between precipitous walls. At intervals the valley will expand to a width much greater than is to be found for many miles above or below; and after holding a practically uniform width for some distance will rapidly contract.

Modifications of this character are usually asserted to be due to the diversified composition of strata through which the river makes its way. To the same cause, too, are assigned the frequent abrupt curves, some of them so sharp that the river seems almost to double back on itself. There are, to be sure, many degrees of hardness and of solubility in all the rocks through which the Ohio has cut its channel; and these properties would certainly be factors in the phenomena observed. But, even where these features are most pronounced, the rock seems to be tolerably homogeneous in its structure; and it does not seem reasonable to suppose that inequalities of this nature would be so capriciously distributed as would have to be the case were they the only or even the principal cause of such conditions.

In recent years much thought has been given to these questions, and some investigations conducted mainly by Prof. Tight as shown by his article have given us the key to the problem. It is very easily answered; being simply the fact that prior to the glacial period the Ohio as a separate stream had no existence. Its present channel was occupied by a series of disconnected water courses, varying in size from small ravines to large rivers. The expansions in its course are the valleys of the larger pre-glacial streams; the abrupt curves and numerous windings result from the efforts of the stream to find the lowest level in broken and irregularly eroded country across which it must seek a path from one valley to another; and the narrows or gorges mark the places where it broke through the minor watersheds that obstructed its progress.

The following pages contain the result of examinations made within the past two years, under the auspices of the Ohio Academy of Science. There are some references in the text that

will inform the reader who wishes to pursue the subject further, where to obtain additional information.

Professor Tight whose previous researches have been largely carried out in the Muskingum and Hocking valleys has extended his work down the present Ohio valley as far as Manchester, in Adams county, where he locates a col which marked the line of division between the waters flowing east in the present bed of the Ohio and those flowing west. As some statements in the present paper can not be understood by those who are not aware of his discoveries in this region, it may be well to say that he has demonstrated that Kanawha river in preglacial times flowed westward from St. Albans, past Guyandotte, to the Scioto, and followed that valley northward. Into this river flowed all the creeks and rivulets rising east of the Manchester col. Beyond Circleville it has not been traced, as the old valley is obliterated by the drift deposits of the ice-sheet. Some data are at hand, however, as mentioned in Professor Bownocker's paper, indicating that it pursued a westerly course and left the State somewhere about the Celina reservoir.

The history of the Little Miami, as worked out by Professor Bownocker, is important in that it shows the general tendency of the drainage of southern Ohio toward the north and west. This would not be the case unless there was an outlet for the waters in that direction, such as old Kanawha seems to have furnished.

The chief value of Doctor Todd's article is to be found in the evidence which it presents that vast changes following the advent of the ice-sheet were by no means confined to the immediate region of the Muskingum and the Ohio, but reached to the borders of the Lakes, thus showing a probable northern outlet for the waters in that direction also.

The concluding paper treats of the Ohio river from the point where Professor Tight leaves it. The old waterways in this section being more plainly marked and less complicated than they are further east, the labor of deciphering has been less difficult.

A great field is opened up for those who are to continue these researches. There is probably not a stream in the State,

ancient or modern, which has not been more or less modified by the influences described, even to the extent, in many cases, of owing its origin to them. The work will be incomplete so long as any portion of the State remains uncharted. And it must extend still further before a complete history of the Ohio river can be written. As yet, we know nothing of the pre-glacial conditions below Louisville, or of the tributary streams in southern Indiana and western Kentucky.

It may not be out of place to call attention here to a matter which seems to have escaped notice heretofore.

The oldest land in Ohio is that along the Cincinnati axis, in the western part of the State. From here, through three geological eras, the Upper Silurian, Devonian, and Sub-Carboniferous, the slope was toward the southeast; consequently the surface flow must have been in the same general direction. It is quite possible that to this epoch are to be assigned the older erosion planes mentioned by Professor Tight in his present paper. Not only in Ohio, but in the neighboring States as well, are to be observed these old levels at an average elevation of about two hundred feet above the present streams. The suggestion is ventured that these represent drainage lines as they existed prior to the Appalachian uplift. Such valleys must have formed in the immense length of time during which surface waters sought the constantly receding ocean that bordered the swamps of the coal measure period. When these were uplifted into mountain ranges, the elevation must have been general enough to produce a considerable effect upon the region to the westward. Otherwise a trough would have resulted between the land just emerging from the sea and that which had so long stood above the waves. Had this been the case, it would seem that the ancient rivers must have turned toward either the north or the south, and flowed around the island on which they had their birth. Instead of this, however, we find the entire drainage of the newly risen country flowing back directly across the formations whose waste had assisted in building it up. It is a plausible supposition that the high level valleys pertain to a pre-Carboniferous drainage toward the southeast; while some at least, of the narrow and deep valleys cut through

or along them are features of a reversed drainage, of pre-glacial age, toward the northwest; and that it is the latter which has been again reversed and sent off to the southwest by the continental ice-sheet.

A serious objection, and one which may be fatal to this suggestion, is the great length of time that has elapsed since the Appalachians were formed. This is sufficient for subsequent erosion to have effaced all inequalities of level which prevailed in the central valleys at that period. However, minor oscillitations may have occurred which would preserve or perpetuate the older valleys.

At any rate, whether any evidence now remains of it or not, there must have been a former drainage from western Ohio toward the eastward; and this drainage must have become reversed when the Allegheny plateau was raised to a sufficient elevation. The only escape from such conclusion is in assuming that all the teachings of our geologists, previous to this time, concerning the succession of formations, are erroneous. While very many errors, due to lack of data, have crept into our text-books, the sequence of geological deposits in this region seems well established. If not so early as herein intimated, these high-level valleys may still belong to a drainage period antedating either of those discussed in these papers.

GERARD FOWKE.

DRAINAGE MODIFICATIONS IN WASHINGTON AND ADJACENT COUNTIES.

By G. W. Tight.

INTRODUCTION.

The study of the region treated of in this paper was undertaken as the natural out growth of the work previously done in the surrounding sections. The correlations of the preglacial drainage in the areas to the east, north and west left this region of the lower Muskingum somewhat isolated and very naturally raised the question as to its preglacial conditions of drainage. On account of the position which the region occupies, the restoration of the old drainage has a very important bearing on the interpretations already worked out for the surrounding regions. The problem is one which was recognized by Prof. E. B. Andrews and referred to in the second volume of the Ohio Survey, where he says: "The drainage features of the county (Washington) present some very interesting facts. The Ohio River, Little Muskingum, Duck Creek ,and the Muskingum all converge towards a common center, the last three uniting with the former in Marietta township." "The slopes of nearly half a circle find their lowest point at a common center in Marietta township." And after a brief description of the stream courses he further states: "Thus it will be seen that the county presents a great variety of surface slopes. In the eastern half of the county the slope is southwestern and southern, while in the western, i. e., west of the Muskingum, it is chiefly northern and southwestern. While the general drainage of southeastern Ohio is to the southeast, the large streams, like the Muskingum and Hocking, flowing in a direction approximately at right angles to the direction of the Ohio, yet in Washington county we have almost every variety of direction." "What originally determined the flow of streams in these different directions it is impossible now to determine. In some parts of the state the dip of the strata determines the direction of drainage, but this can not be the case to any large extent in Washington county." And

again: "It is true that the direction of streams is, for limited distances, determined by the character of the strata of rocks in which they flow, the softer rocks yielding a passage while the harder resist. This will explain many of the crooked ways of our streams which would be otherwise utterly inexplicable. But this cause could not have determined the general direction of the streams in Washington county."

In Dr. S. P. Hildreth's Geological Report for 1838 he states, after a brief description of the old valley floors in this region: "From the frequency of these flat lands between the headwaters of the Little Hocking and the south branch of Wolf Creek, it is quite possible that at some remote period the waters of Wolf Creek were discharged into the Ohio instead of the Muskingum." "Great changes, evidently, have been made in the direction of all our water courses before they found their present levels."

While it is apparent that the earlier geologists partially recognized the problems presented by the typographic features of the region and made some observations and deductions there seems to have been no systematic endeavor to follow up the study.

As considerable field work, scattered through several years, had already been done in the region by the author, it was with pleasure that he suggested to the trustees of the Ohio State Academy of Science, upon their request for information concerning the problems in the field of geographic geology of the state, that this region be further studied, with a view to the more complete correlation of the data in hand and the publication of a report of the same. By the action of the trustees a grant was made to the author which enabled him to spend five weeks in field study. This grant was from the Hon. Emerson E. McMillin Special Research Fund of the Ohio State Academy of Science.

The field studies conducted under this grant in connection with the work previously done have enabled the author to make what he believes to be a correct solution of the problem of the preglacial drainage of the region.

While the conclusions reached, as a result of this work, seem to be thoroughly established, still the work can be con-

sidered as only fairly begun and this report is scarcely more than a preliminary statement which it is hoped will give a general view of the field and serve as a stimulus to more thorough and detailed work. Many interesting and important questions remain still to be answered by more extended field study. Some of these are indicated on the accompanying map. It is not expected but that, here and there, minor modifications of the results presented may arise from this more careful and detailed field study, but the main features of the preglacial drainage seem to be so thoroughly established as to leave little room for doubt in regard to the correctness of the general correlations. The matter will be presented very largely in the order in which it was worked out in the field studies. Some references will be made to earlier work and observations, but it is not intended that this shall be in any sense a completed monograph of the region. Most of the facts presented in the text find their expression in the accompanying map (Plate I) and illustrations in a form which will give to those not familiar with the region a clearer idea of the results. Much of the detailed data is purposely omitted from this paper and only such are given as bear directly on the general conclusions.

The author desires to take this opportunity to express his thanks to the generous donor of the Special Research Fund for this practical interest in pure science, and in the Ohio State Academy of Science, and to the trustees of the fund for their confidence in his ability to wisely expend the portion allotted to him. And furthermore, to express the hope that the results herein presented will prove of sufficient value to warrant this generosity and confidence.

LOCATION OF THE AREA.

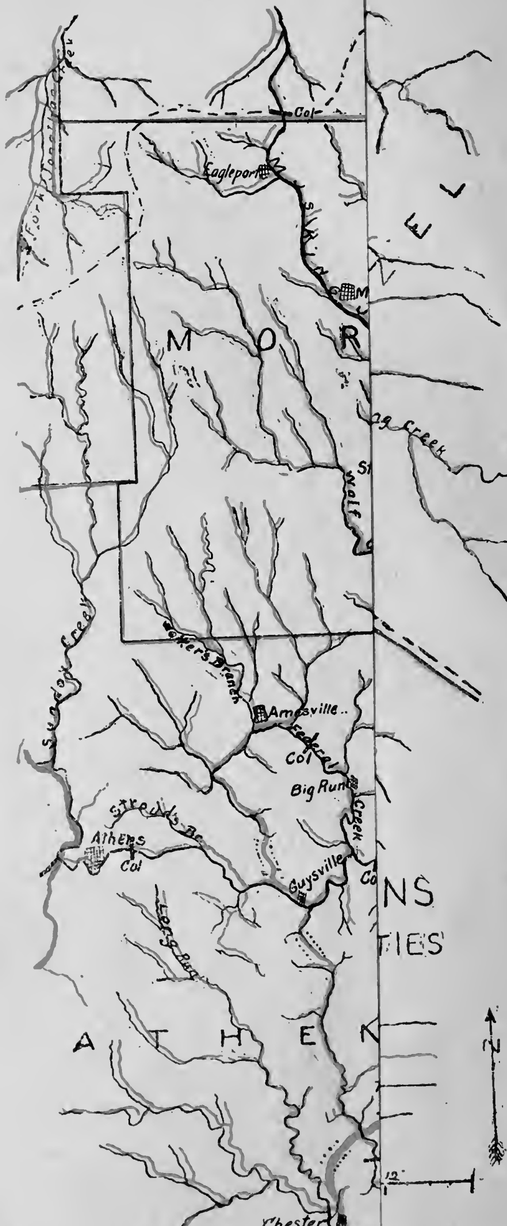
The region under consideration embraces all of Washington county and parts of all the counties which bound it in both Ohio and West Virginia. It includes the territory drained by the section of the Ohio from New Martinsville, W. Va., to the mouth of Shade River, Ohio, except that portion of the Muskingum above the north line of Morgan county, and of the Hocking above Athens, in Athens county. The section lying north of the

Ohio River and west of the Muskingum River has received most attention, as within this area the most important changes of drainage have taken place. Only a limited amount of time has been given to the section east of the Muskingum, in the Duck Creek and Little Muskingum basins, so that scarcely more than a few suggestions are offered concerning the modifications which have there taken place. The entire area considered lies far outside the glacial boundary of Professor G. F. Wright and the only deposits of glacial material are the gravel trains along the Ohio, Muskingum and Hocking and a few scattered erratics which occur at various elevations on the inter-fluvial tracts.

RELATION TO ADJACENT DRAINAGE.

Immediately to the north of this region is a large area now drained by the Muskingum. The preglacial drainage of this northern part of the Muskingum River has already been traced with considerable detail and the results published in the Bulletins of the Scientific Laboratories of Denison University, Volume VIII, Part 2, page 35; Volume IX, Part 2, page 33, and Volume XI, Article VIII. In these reports it is shown that the preglacial drainage consisted of a main stream which had its head in the upper waters of the Tuscarawas and flowed southeasterly past Dresden, Newark and into the present Scioto basin near Lockbourne, south of Columbus.

Into this main valley emptied many tributaries. Only three of these are of especial concern in this connection. They are, first, the Wills Creek valley which heads directly north of the Duck Creek basin and extends northward into the Tuscarawas above Dresden. This valley has not as yet been studied and it may be that the present valley is composed of several preglacial elements. Wills Creek has a very crooked course and as far as the data in hand now show, is an aggrading stream. It presents many interesting features well worthy of more careful study. Secondly, just west of the Wills Creek basin is the portion of the Muskingum River from the north Morgan county line to Dresden. It is shown in the works already referred to that this section of the Muskingum is reversed and that in preglacial times there was a col on the Muskingum at



Col
Eagleport
M O R
Amesville
Col
Big Run
Creek
Guysville
Athens
Col
Chester
A T H E N
NS
TIES
N

the north Morgan county line and from this col there was a small tributary ran northward into the main preglacial axis.

The third section is that of the Jonathan Creek which was tributary to this reversed Muskingum section at Zanesville. The headwaters of these northward flowing streams are shown on the accompanying map (Plate I).

To the east of the region lies the drainage basin of the Monongahela and upper Ohio. The modifications in this section have been very great and have been the object of study by many geologists. A summary of the work done by the earlier students, with newly added data, is given by Dr. T. C. Chamberlin and Mr. Frank Leverett in the American Journal of Science, Volume XLVII, No. 280. According to these authors there was an old col on the Ohio a little below New Martinsville, W. Va. Fishing Creek being the headwaters of the stream which flowed northward up the present Ohio's course above New Martinsville into the then northward discharging Monongahela. The region to the west and southwest remains open to further investigation.

CHARACTER OF THE BOUNDING WATERSHED.

The watershed which surrounds the region is a well marked topographic feature and quite regular in its general outlines. It rises to a nearly uniform elevation, being somewhat higher to the southeast and lower to the northwest. To the southeast it forms the divide between the tributaries of the Ohio and the Monongahela. It forms everywhere a high dividing ridge, except at the several points where it is cut through by the present drainage lines. Here the streams have narrow, gorge-like valleys and the elevation of the ridge persists surprisingly near to the stream courses. While the cols crossed by the streams must have been low they were evidently quite narrow gaps or else the ridge would show more of a lowering at these points. Only a small portion of the divide is shown on the map and this is cut in but two places, i. e., at the north Morgan county line and below New Martinsville.

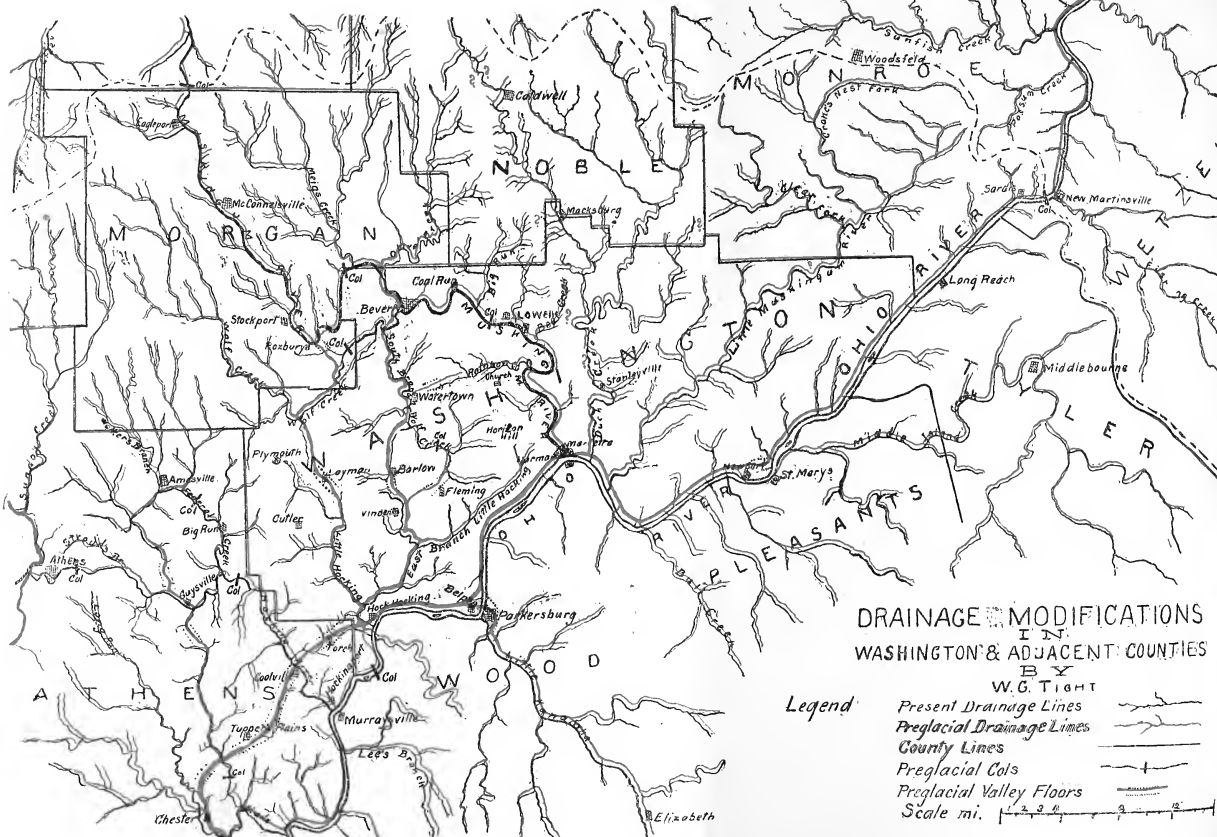

DRAINAGE MODIFICATIONS
IN
WASHINGTON & ADJACENT COUNTIES
BY
W. G. TIGHT
Legend
Present Drainage Lines
Preglacial Drainage Lines
County Lines
Preglacial Cols
Preglacial Valley Floors
Scale mi.
MORGAN
NOBLE
MONROE
WASHINGTON
ATHENS
WOOD
PLEASANTS
TYLER
WETZEL
OHIO RIVER
Woodsfield
Caldwell
Macksburg
Eagleport
McConnelsville
Stockport
Roxbury
Beverly
Lowell
Coal Run
Watertown
Barlow
Fleming
Cutler
Plymouth
Amesville
Athens
Guysville
Coolville
Tuppers Plains
Murraysville
Chester
Parkersburg
Belpre
Hockingport
Marietta
Stanleyville
St. Marys
Long Reach
Middlebourne
Sardis
New Martinsville
Elizabeth
Sunfish Creek
Crane's Nest Fork
Possum Creek
Little Muskingum River
Duck Creek
Wolf Creek
Meigs Creek
Federal Creek
Little Hocking
East Branch Little Hocking
Lee's Branch
Big Run
Col

PLATE I.

DISTRIBUTION OF THE PRESENT DRAINAGE.

The distribution of the present drainage is shown on the map (Plate I) in black. The Ohio is the major stream and this crosses the region in a general southwesterly direction. The next larger stream is the Muskingum which enters the Ohio on the northern side at Marietta. Next in importance is the Hocking which enters also on the northern side of the Ohio and has a general southeastern direction, rather abnormal to the course of the Ohio.

On the southern side of the Ohio the Little Kanawha enters at Parkersburg. East of the Little Kanawha lies the considerable basin of Middle Island Creek, which enters the Ohio just above St. Mary's. To the west and southwest of the Little Kanawha is the basin of the Big Kanawha. The modifications which have taken place on the Big Kanawha are discussed by the author and by Mr. Frank Leverett in the Denison University Bulletin, Volume IX, Part 2, Articles III and IV.

On the northern side of the Ohio and east of the Muskingum are the valleys of the Little Muskingum and Duck Creek, both tributary to the Ohio a little above the mouth of the Muskingum. West of the Muskingum and between it and the Hocking is the somewhat branched system of the Little Hocking. This has two main branches, the North Branch and the East Branch.

East of the North Branch of the Little Hocking and north of the Big Hocking is the basin of Federal Creek. This is a very peculiar stream as it flows in almost a circular course with many radial tributaries, those on the north side of the circle being much longer than those on the south side.

South of the lower portion of the Hocking is the Shade River system with its three main branches, East, Middle and West Forks.

The only other considerable stream in the region is Wolf Creek. This rises in northern Morgan county and flows southward and eastward and enters the Muskingum at Beverly. A short distance above its mouth it receives a tributary of consid-

erable size, South Fork. This tributary parallels the Muskingum for many miles but flows in the opposite direction.

It is seen that the present drainage is very much diversified and abnormal.

GENERAL TOPOGRAPHIC FEATURES.

The topographic features of the region are quite as varied as its drainage distribution. The present forms, being the resultant of at least two cycles of erosion, which in many ways were quite discordant, show every variety of combination of parts of each cycle. A few miles northwest of Marietta there is a group of very high points in the ridge which separates the headwaters of the East Fork of the Little Hocking and the South Fork of Wolf Creek, from the waters of the Muskingum and Ohio.

This ridge is the northward continuation of the high ridge in West Virginia which separates the waters of Middle Island Creek from those of the Little Kanawha. On a very high portion of this ridge and several miles north of Marietta is located a large Catholic Church which has a tall spire tipped with a gilded cross. This church serves as a convenient land mark for a radius of from twenty to thirty miles. A little south of the church on this same ridge is a high hill, marked on the map (Plate I) Horizon Hill, for from its summit there is an unobstructed view in every direction for many miles. From this elevated point of view the general surface of the region is seen to rise to the north, east and south and to sink to the west, in the direction of down the Ohio and the East Fork of the Little Hocking. With this general surface configuration all the larger streams are in general accord and suggest at once that their direction was largely determined by the slope of the general surface of the upland plain. From this high elevation the deep, narrow valleys that traverse the region are lost in perspective and a very fair picture is obtained of the old features as they existed before the work of the deeper erosion was accomplished. This old land surface was a gently rolling plain. The valleys were very broad Vs in cross section and the ridges and hills were low. The entire relief of the region ranged between 150-200

feet. The old slopes were well graded and the angles of slopes very low. It would have been considered very fair agricultural lands. A photograph taken from our standpoint gives a good idea of the features of this old form. The surface is seen now dotted with farm houses and the cultivated lands of the region are principally located on this old surface.

On closer inspection it is observed that this rolling surface is very deeply scarred by an extensive net work of narrow, deep valleys which are present almost every where over the region; the principal exception being along the present divide separating the waters of Wolf Creek from those of the Little Hocking. The reasons for this notable exception will appear later. In many places these deep valleys are scarcely more than narrow gorges. They vary in depth below the old surface from 100 to 250 feet, depending upon their proximity to the larger streams. Their slopes are so steep that they are rarely cultivated but are usually covered with timber. They are such a barrier to the construction of roads that over large areas there are two almost distinct systems of highways, one the valley roads and the other the ridge roads. These often parallel each other for many miles without connection. The valley roads pass over the ridges at the head water gaps where they are usually crossed by the ridge roads. There is everywhere a well marked change in the angle of the slopes between the old surface and the deeper valleys, indicating very clearly the line between the old erosion cycle and the more recent. So that the fact that the region has experienced a very wide spread rejuvenescence is very apparent.

The exceptions to these general features are rather local and require a more detailed treatment. They are the flat low lands associated with the present divides and the broad valleys of the larger streams.

CHARACTERS OF THE OHIO VALLEY.

The Ohio River valley where it enters the region in the vicinity of New Martinsville, is a very narrow gorge.

The bordering hills are very steep, often exposing vertical cliffs which rise to the level of the adjacent table land. The river

1

2

3

1. View on the Ohio, looking up the 16-mile stretch at Long Reach.
2. Near view of Second Hill on Left Bank in 1. New Slope to the River. Old Slope away from the River.
3. View looking north across the Little Muskingum Basin. Characteristics of bird's eye views of South Eastern Ohio.

PLATE II.

can scarcely be said to have a valley in the general usage of the term, for it is hardly more than a passage way through a rough and hilly country. The bottoms along the sides of the stream are very narrow or entirely wanting and the high water stages of the river wash the talus slopes on both sides of the river. Figures 1 and 2 of plate II show some of the features of this part of the valley.

Passing down the river towards Marietta, the valley becomes gradually wider and the bordering hills less high and abrupt. This is more noticeable where the larger streams enter the Ohio. There is a sharp bend in the valley at the mouth of Bull Creek where the river turns north towards Marietta and again at the mouth of the Muskingum at Marietta where the valley turns again towards the southwest. A little below Marietta there is a very considerable narrowing of the valley. This is so apparent that it is quite suggestive that possibly this might be the location of an old col in the ridge that separates the Middle Island creek and Little Kanawha basins and which appears so strongly developed on the north side of the Ohio between the head waters of east fork of little Hocking and the Muskingum.

A little below Marietta the valley turns to the south as far as the mouth of the Little Kanawha at Parkersburg. Throughout this portion the valley is quite broad but still the valley walls are quite steep and precipitous. In making the great bend at Parkersburg the river has cut back the hills on the West Virginia side so that the valley has extensive bottoms on the Ohio side. The valley width remains about constant from Parkersburg to the mouth of the Little Hocking but it narrows very rapidly from that point to the col marked on the map above the mouth of the Big Hocking. At this col the valley is only about three quarters of a mile wide and vertical cliffs form the valley walls. Below this col the valley broadens again gradually towards the southwest.

CHARACTERS OF THE MUSKINGUM VALLEY.

The Muskingum River crosses the north Morgan county line in a very narrow gorge-like valley. The bordering hills present very steep, often vertical faces to the river and rise from 250 to 350 feet above it.

Passing southward the valley gradually broadens through Morgan county and reaches its maximum width, in this section, near Roxbury where it bends sharply to the north and becomes rapidly narrower and its walls more precipitous until at the col near the sharp bend to the south (Figure 2, plate III,) the valley is a narraw gorge. After passing the mouth of Meigs Creek the valley broadens again to the mouth of Wolf Creek, at Beverly, from which point it begins to narrow again on passing further down the stream, until it reaches a minimum at the point marked col on the map, a short distance above Lowell (Figure 1, plate III). From Lowell onward to its mouth it increases in size and width until at Marietta the valley is as large as that of the Ohio itself.

Throughout the course of the valley there are extensive gravel terraces in the broad and open portions but these are entirely absent in the narrow section above Meigs creek and but very slightly show in the Lowell narrows. These terraces are the gravel trains which head far up the Tuscarawas and Licking in the morainic belts of the glaciated area.

CHARATCERS OF THE LITTLE MUSKINGUM AND DUCK CREEK VALLEYS.

These valleys have not been studied as carefully as the others and only their very general features are referred to. The vallay of the Little Muskingum is rather narrow throughout its entire length. It shows a marked tendency to broaden out at the points where it receives its largest tributaries. It is cut out of the floor of a broad basin-like valley of the old land surface. One of its remarkable features is its close parallelism to he Ohio through its entire length. A view from the divide which separates the Little Muskingum from the Ohio, (Figure 3, plate II), shows at a glance that the old valley of the Little Muskingum was very much larger and had reached a more advanced stage of planation than that of the stream which was later occupied by the Ohio. A view looking northward from this divide across the Little Muskingum country is in very striking contrast to one looking southward across the Ohio.

PLATE III.

1

2

1. Lowell Col on the Muskingum.

2. Meigs Creek Col on the Muskingum.

TIGHT — Drainage Modifications.

The valley of Duck Creek resembles much that of the Little Muskingum. The lower part of the valley is much broader and the hills more rounded than in the middle and upper sections. This lower course has the appearance of recent occupancy by a larger stream than originally cut the valley. This fact associated with some of the features farther up the valley suggests that there have been several modifications of the streams but they have not been fully worked out and are left with question marks on the map. The suggestions indicated on the map will serve as a working formula for further investigation.

CHARACTERS OF THE WOLF CREEK AND LITTLE HOCKING VALLEYS.

Wolf Creek heads in northern Morgan county on the divide which was crossed by the Muskingum when it broke over into this basin. It flows soutward many miles closely parallel to the Muskingum, much as the Little Muskingum parallels the Ohio. Its valley is narrow and deep. It broadens gradually towards the south of the point where it turns eastward when it narrows rapidly to the col a few miles above its mouth. Near the mouth of the valley; just above the junction of its South Fork there is an old deserted ox bow of considerable interest. This ox bow seems to have been cut off at the time the flood waters cut out the col above. The valley is quite narraw at the cut off, The hill which occupies the center of the ox bow rises almost as high as the surrounding general surface. Below the mouth of the South Fork the valley is very broad and the hills more rolling.

This valley does not seem to have ever been cut down to the level of the deep channel of the Muskingum. It seems as though the lime stone stratum which forms the floor of the valley at its mouth had prevented the valley from becoming well graded to the level of the deeper channels of the larger streams.

The valley of the South Fork of Wolf Creek is very markedly different from that of the main creek. Throughout most of its length this valley is comparatively broad and open and bounded by more gently rolling hills. At places the walls are rather steep but that is the exception rather than the rule. In the upper waters the contrast with the head water features of the

main stream are most striking. The country around the head waters is rather flat or gently rolling with very deep soils. Many of the smaller tributaries rise in extensive swamp areas. These swamp areas often lie on the divide which separates the waters of Wolf Creek from those of the Little Hocking. The slope of this divide on the north side which is drained by the tributaries of Wolf Creek is much less dissected than the south slope which is drained by the tributaries of the Little Hocking.

The Little Hocking valley is divided into two main branches which are very similar to each other in characters and present no special modifications from the normal. They are rather narrow with moderately steep valley sides. Every where are present the marks of the recent rejuvenescence. The valley of the East Fork occupies much the broader depression in the old land surface. Several of its tributaries on the north side, like the head waters of the South Fork of Wolf Creek, rise in the flat tracts on the same divide. The tributaries on the south side of the East Fork are all short, as the East Fork, like the Little Muskingum, parallels the Ohio throughout its entire length and is separated from it by a high ridge but a few miles wide.

CHARACTERS OF THE HOCKING VALLEY BELOW ATHENS.

At Athens there is a large loop in the Hocking River and the valley is quite broad. Some distance below the city the present river has crossed an old col. The valley is not as narrow as might be expected but the presence of the old col is shown by the vertical cliffs that face the river and the persistency of the old water shed at its maximum elevation, up to the very walls of the valley.

Below this col the valley gradually widens and the walls become less precipitous, although they remain quite steep, to the bend at Guysville. Below this point the valley gradually narrows again to the mouth of Federal Creek. Below this the narrowing is much more abrupt and at the point marked col on the map the valley is a very narrow gorge with vertical rock walls. There were here several channel ways during the cutting out of the old col by the present river. Some of these were cut nearly

PLATE IV.

Hocking Valley, a few miles above Coolville.

to the present level of the river so that the bold rock cliffs and the numerous deep ravines present very picturesque scenery. Below this col the valley gradually broadens again and the walls become less precipitous as far down as Coolville, (plate IV). Between Coolville and its mouth the river again passes through a narrows. That the narrows at this point is the site of an old col is not so evident as in the other cases farther up the river.

CHARACTER OF THE FEDERAL CREEK VALLEY.

A study of this valley was not included under the outline planned for the work for the Academy, but it soon became evident, from the field work, that under one of the working hypotheses it might prove to be in the line of discharge of the waters of the Muskingum, so that its investigation became necessary. The divide separating the waters of Federal Creek from those of Wolf Creek and the Little Hocking was carefully examined for an abandoned valley floor, but none was found. There are some low cols in the divide which may possibly have been occupied by water during some of the high water stages associated with the drainage modifications.

The valley of Federal Creek is rather deep and narrow in its lower portion, but in the section around Amesville is much broader. All the tributaries on the northern side occupy rather broad valleys. The effects of the rejuvenescense which are so marked a feature throughout most of the region are less apparent in the Federal Creek basin than anywhere else in the entire region. The data upon which rests the location of the old col below Amesville are not as satisfactory as could be desired. The location is made more from the necessities of the case than from field observations.

CHARACTERS AND DISTRIBUTION OF THE OLD VALLEY FLOORS.

It is very evident that as soon as a river deserts any part of its valley, the abandoned portion will develop at once into a divide from which the waters will flow each way into the remaining sections of the river. This will be especially true if from any cause a river course is divided and one portion caused to

reverse its direction of flow. It therefore becomes a common characteristic of these abandoned valley floors that they are located on present divides and it follows that wherever found, the old streams crossed the present divides at such points. They will therefore be discussed in connection with the divides in which they occur. As already mentioned, these flat low lands associated with the present divides form one of the notable exceptions to the general topographic features. The most striking case of this kind is the divide which separates the waters of Wolf Creek from those of the East Fork of Little Hocking. In this divide there are three well marked cases and several less notable ones. Those at Layman, Barlow and Fleming are the most important. They were the subject of study by Dr. S. P. Hildreth who wrote as follows in his report of 1838 concerning the valley at Barlow.

"On Mr. Lawton's farm, in Barlow, township, Washington county, in the midst of the marl region, is a locality of fossil fresh-water shells of the genus Unio. They are imbedded in coarse sand or gravel, cemented by ferruginous matter. The spot on which they are found has once evidently been the bed of an ancient lake or pond. It is now a beautiful valley of a mile or more in width by four miles in length, surrounded by low hills. On the south side a small branch drains the superfluous water into the Little Hocking. In digging wells for domestic use in this tract, beds of sand, gravel and plastic clay are passed to the depth of thirty feet, containing imbedded branches of trees, leaves and fragments of wood of recent and living species. Similar valleys and levels are found in the uplands of the western part of the county, lying between the headwaters of the creeks, and are a kind of table-land. From the frequency of these flat lands between the headwaters of the Little Hocking and the south branch of Wolf Creek, it is quite possible that at some remote period the waters of Wolf Creek were discharged into the Ohio River instead of the Muskingum. This opinion is strengthened from the fact that the head branches of the South Fork now rise within two miles of the Ohio, and run northerly, parallel with and opposite to the course of the Muskingum for twelve miles, and joins that river twenty miles

from its mouth. The remains of its ancient beds would form pools and ponds of standing water, furnishing fit residences for the fresh water shells, whose fossil remains are now found there. Great changes evidently have been made in the direction of all our water courses before they found their present levels."

The valley floor at Layman is not quite as large as that at Barlow, but it did not carry as large a stream. Several fields in this old valley floor show still, under cultivation, a black valley soil and the writer was informed by Mr. J. A. Gage, of Layman, that at one place there is a deep muck from which much decayed wood has been taken and the waters issuing therefrom have a very disagreeable odor.

The old floor at Fleming is still smaller than the others and probably carried a smaller stream. The full depths of the silt deposits that cover these floors was not determined as all the wells examined were very shallow. The bordering hills associated with these old valleys were very low and well graded and usually carried very deep soils which they often retain at present, where not exposed to the erosion of the more recent cycle.

Not directly in this divide but associated with the Wolf Creek basin is another abandoned valley floor near Watertown. This floor lies about two miles northeast of the town and about a mile east of the South Fork of Wolf Creek. Rainbow Creek heads on this floor. Whether all or only a part of the stream which occupied this Rainbow Creek valley drained over this floor is as yet undetermined. If there were other cols on the Muskingum below Lowell and the reversed Rainbow Creek carried a section of the present Muskingum, they will require very careful detailed work to determine, as the erosion of the valley of the Muskingum has been so great in this portion that almost every trace of such cols has been lost. There are some indications in the character of the divides which would seem to locate one such below the mouth of Bear Run. If this should be certainly located it would follow that both Cat Run and Bear Run drained through Rainbow Creek reversed and over the old Watertown valley floor. The location of this col is not indicated on the map as it was not considered sufficiently well established.

In the divide separating the waters of Wolf Creek from the Muskingum, just south of Roxbury, there is a very low col which while it presents few features characteristic of most of the old valley remnants, still it seems quite certain that it represents the location of an old abandoned valley. The divide at this point is so narrow and the amount of erosion of the large streams on each side is so great (about 150 feet), that nearly all the old valley characters have been lost from excessive erosion.

In the divide separating the lower waters of the Hocking from those of the Little Hocking there is a well preserved valley floor (Figures 1 and 3, Plate V) which has been sectioned in several places by the cuts on the Baltimore and Ohio Southwestern railroad. The best section is but a few rods west of Torch station where the cut is about twenty-five feet deep and very near the center of the old valley and in the present crest line. The section shows above the tracks, about fifteen feet of very fine clay, scattered through which are some small decayed pebbles. Except for the absence of foreign material this clay resembles very much a glacial till. No lamination was observed and it was thought to be a very deep residual soil. Above this clay is a layer of from two to three feet of river gravel composed mostly of small material varying from a quarter of an inch to four inches in size and mostly flattish or lenticular in form. Its local origin from the carboniferous sandstones and shales is very evident. The sandstone pebbles are more nearly equiaxial than the pebbles of the shales. All of this gravel is so thoroughly decayed that good sized pebbles can be easily crushed between the fingers. The section did not show any well marked evidence of shingling, but was very certainly stream-made and stream-laid. Above the gravel is about a foot of rather red clay soil and above that some six to seven feet of loëss-like silt. The rock is not revealed in the bottom of the cut so that the exact depth of the filling was not determined. However it is thought not to be very deep below the railroad track to the rock, judging from other sections to the east and west, which do not show so much clay but do cut into the rock. In some of these cuts the gravel lies directly upon a decayed rock surface without the thick clay beneath.

1

2

3

1. Preglacial Valley at Torch.
2. Preglacial Valley at Tupper's Plains.
3. From the Valley of the Little Hocking looking towards Torch, down the Preglacial Valley. Ohio River on the left in the distance.

One of these sections about a mile east of Torch shows about eight feet of a sandy clay graduating into the much decayed underlying rock and overlain with about two feet of gravel and this with about five to six feet of the loëss-like silt.

Both east and west of Torch the old valley floor is deeply cut by recent erosion into many very picturesque ravines and gorges. This is especially true on the west. The railroad follows up one of these ravines from the valley of the Hocking onto the old valley floor making a grade of about 125 feet in about two miles. This old floor extends westward to the Hocking and crosses the Hocking valley at Coolville. A cut on the pike in the main street of the village shows a fine section of the gravels in which the shingling to the southwest is very marked.

From Coolville the old valley is a very conspicuous feature in the typography as it extends southwestward past Tupper s Plains (Figure 2, Plate V) and into the basin of Shade River. Between Coolville and Tupper's Plains the old valley floor is deeply cut by a small tributary of the Hocking. At the Plains the old floor forms a part of the divide between this tributary and the East Fork of Shade River. A few wells sunk in the valley penetrate from twenty to thirty feet of clay silts to a water bearing sand or gravel layer.

Two other remnants of old valley floors may be referred to, though somewhat beyond the exact limits of the major topic of this report. One of these lies between the headwaters of Rush Run, a tributary of Federal Creek, and the Hocking; the other on the divide separating the middle fork of Shade River from the Hocking and about a mile south of Guysville. These are of importance in connection with the drainage changes of Federal Creek and the lower part of the Hocking below Athens.

RESTORATION OF THE OLD DRAINAGE SYSTEM.

With the general features of the region, the position of the old eroded cols, which cross the present valleys, and the positions of the remnants of the old valley floors, thus very briefly presented, it seems possible to trace with a considerable degree of certainty the old drainage system. This is represented on the map in red. This reconstruction is based on many detailed

observations of elevations and gradients of the old valley floors, and measurements of valley widths and amounts of erosion, which it is not possible to present in a sketch of this kind.

It will be seen by a glance at the map (Plate I) that the old system coincides with the present drainage along most of the smaller streams. Middle Island Creek and the Little Muskingum were the main headwater branches.

Tributary to Middle Island Creek was a small stream which headed at the New Martinsville col and flowed along the present course of the Ohio as far as Newport. The northward deflection of the old drainage at the mouth of Bull Creek was probably caused by the great strength of the ridge separating the latter from the Little Kanawha basin already referred to. Below the mouth of the Little Muskingum the Duck Creek tributary entered. This was probably smaller than the stream in the present Duck Creek valley. The next tributary was that of a stream which carried the drainage of the section of the Muskingum below Lowell and probably much of that of the headwaters of the present Duck Creek. The Little Kanawha was the next stream to enter the main line which followed along the present Ohio. Just at Parkersburg the Little Kanawha is deflected somewhat to the west of its former line of discharge, the old outlet being blocked with deep clay deposits. Below Parkersburg the old stream followed the present Ohio as far as the mouth of the Little Hocking. Here it received a branch almost, if not quite, as large as itself. This branch comprised several elements. The first one on the east was composed of the drainage from the head water region of the present South Fork of Wolf Creek which crossed the old valley floor at Fleming into the present valley of the East Fork of the Little Hocking. The middle element was made up of the Meigs Creek, Olive Creek and Big Run drainage and the section of the Muskingum above Lowell and below the Meigs Creek col. These waters entered the mouth of Wolf Creek and followed down the East Fork reversed and through the old valley at Barlow into the East Fork of Little Hocking.

The western element included the present basin of Wolf Creek and that section of the Muskingum between the north

Morgan county line and the Meigs Creek col. These latter waters crossed into the Wolf Creek valley through the gap south of Roxbury and thence southward through the old valley at Layman into the Little Hocking.

Below the mouth of the Little Hocking the old stream passed through the old valley floor at Torch, crossed the Hocking at Coolville and thence through the old valley at Tupper's Plains into the basin of Shade River. At Coolville it receives a short tributary, along the line of the Hocking which headed at the col below the mouth of Federal Creek.

Along the line of the present Middle Fork of Shade River the old stream received the waters from the section of the Hocking blow the Athens col, including also those of the Federal Creek basin. These waters crossed the ridge through the gap south of Guysville. Concerning the further course of this old river it may be stated that since the work was completed which forms the basis of this report, much more field work has been done and it is known that the old river passed westward across southern Ohio and found its way into the Scioto. A more detailed report is now in preparation covering the entire history of this old valley. The normal characters of this old system are shown on the map Plate VI, which presents the old drainage separated from the present. It is noticeable that this old normal drainage conforms very closely to the slopes of the old upland surface.

THEORETICAL CONSIDERATIONS.

Within the limits of this paper it is not possible to discuss at length the probable factors involved in the production of the modifications of drainage from this old restored system to the new or present form. However, it may not be out of place to offer a few suggestions of a theoretical nature with the hope that they may be helpful in the further study of the phenomena themselves. The first and most natural question that arises is, if the restoration, as worked out, truly represents the conditions of drainage prior to the present, what produced the change? The answer to this question may not be found in the study of so limited a field and the phenomena therein presented. From the work previously done in

adjacent regions it appears that the drainage modifications therein observed were intimately associated with the phenomena of the glacial period. The blocking of the northern discharge of the Monongahela and upper waters of the Ohio by the advancing ice or its extensive deposits turned the waters of the present upper Ohio region over the New Martinsville col into this basin. In a similar way the waters of the Muskingum which originally discharged westward past Newark and into the Scioto were deflected southward over the old col on the north Morgan county line. The conditions in the case of the Hocking are not so clear and at once suggest that there were other factors present besides the simple introduction of these large streams at particular points. For if the waters of the Hocking were set over the Athens col, due to the damming action of the ice or its deposits, on some northward flowing stream, it would seem as though it would have followed down the Middle Fork of Shade River branch of the old drainage and would not have crossed the col below the mouth of Federal Creek. As this region is far beyond the direct action of the ice and the only glacial deposits of note are the gravel trains found in the valleys of the Ohio, Muskingum and Hocking it at once becomes evident that the modifications wholly within the region must have been produced in some other way than by the direct action of the ice or its deposits. Such for example are the modifications of the lower Muskingum within Washington county. If the waters which headed at the north Morgan county line col were flowing over the gap south of Roxbury and through the old valley at Layman at the time the Muskingum waters first crossed this col it would seem that the larger stream would have followed the more direct and open line of the old drainage than to have turned to the north over the Meigs Creek col and again over the Lowell col. It seems necessary to assume one of two possible explanations. First, that there was some obstruction to the old direct line or that the modifications antedate the introduction of the Muskingum waters and that when the waters came over the col they followed the drainage they discovered already established, which was practically coincident with the present system. Of these two explanations the last seems best to fit the facts

as they appear in this and neighboring districts. If then the modifications were not produced by the glacial floods which were poured over the cols into the basin, but antedate the advent of these larger streams, some modifying cause must be found which could have produced the changes under the action of the old drainage itself. The necessary factor seems to be supplied in the silt deposits which occupy the remnants of the old valleys. These silts often exceed thirty-five feet in thickness. They must have been deposited under exceptionaal slack water conditions. It is believed that their deposition on the floors of the old valleys so choked up the old drainage that it was compelled to follow new lines which were often over the low cols in the divides and that these new lines were well established when the glacial waters were poured into the basin. The limits of this paper will not permit the full discussion of the problem, but it is hoped that sufficient has been said to show the very great interest that is involved in the study of the geographic geology of the state and to stimulate further research along these lines by members of the Ohio State Academy and others.

HISTORY OF THE LITTLE MIAMI RIVER.

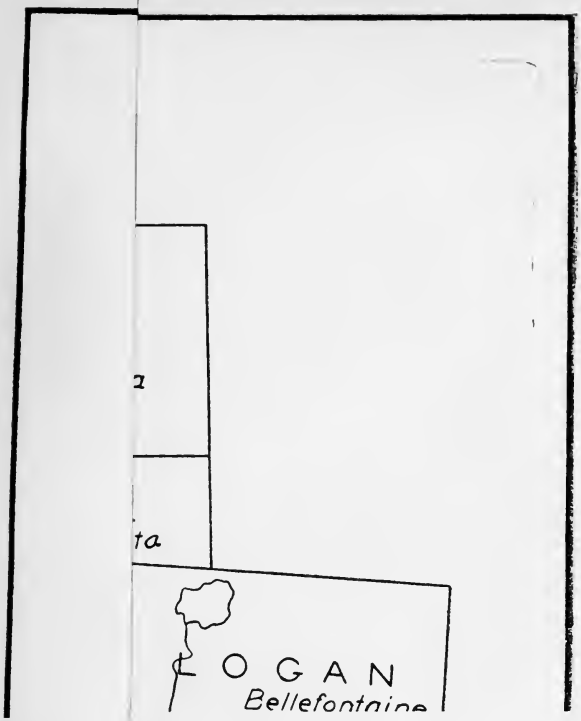
By J. A. Bownocker, D. Sc.

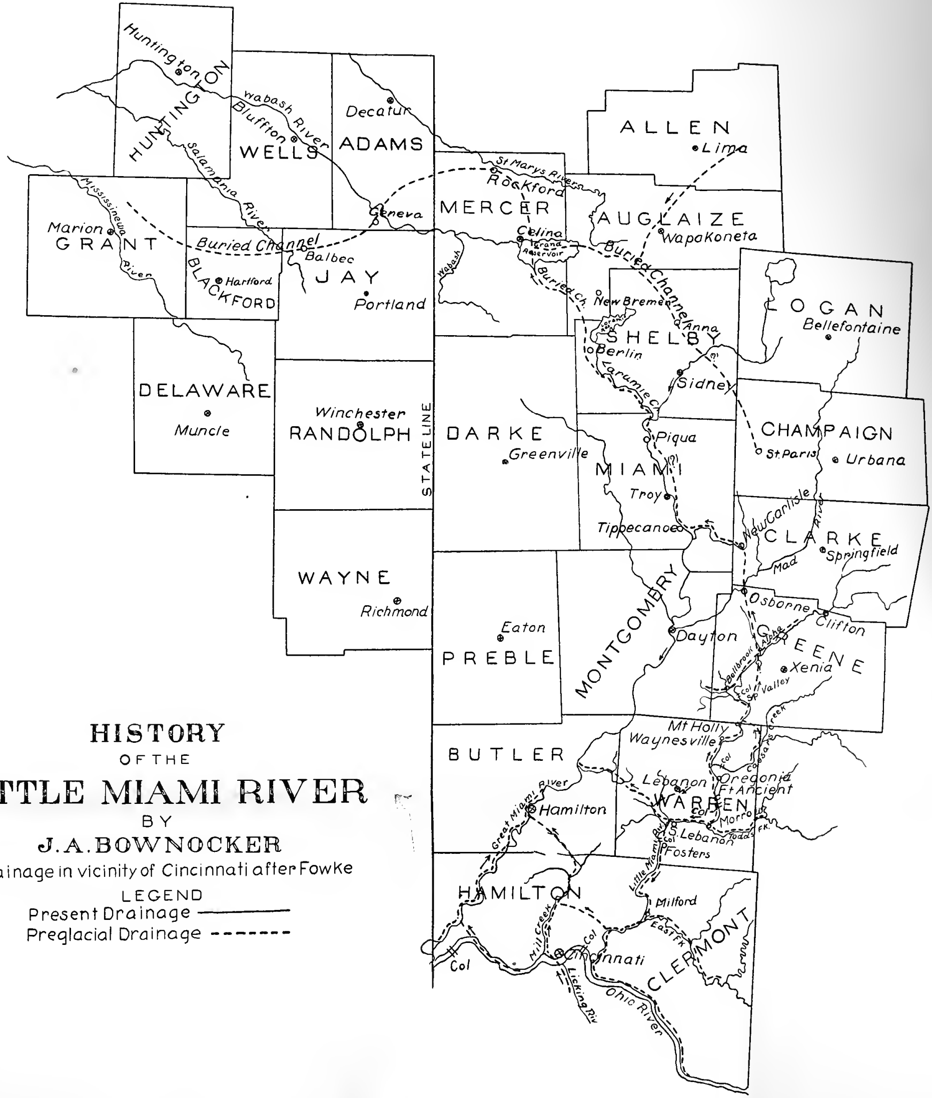
The headwaters of the Little Miami river lie on the glacial plains of western Madison and eastern Clarke counties. The two chief tributaries, known respectively as the East and North branches, unite about two miles north of Clifton to form the Little Miami proper. The valleys of these branches are narrow, but increase in width and depth to the south, though nothing but drift is seen until just north of Clifton where the Niagara limestone appears in the bluffs to the west.

At Clifton the river bids adieu to these commonplace surroundings. Flowing directly over the Niagara limestone, it forms a series of rapids and cascades, and then enters the gorge, which is 80 feet deep, but at the narrowest point not more than one-fourth of that in width. Down stream the gorge widens and at the same time the bluffs become less precipitous. Soon a narrow flood plain appears, and farther down a strip of farm land is found. At Jacobis mill the valley becomes conspicuous. The valley from this place to Clifton may be compared to a greatly elongated V with the apex at Clifton. Everywhere the bluffs are of limestone, making certain that the gorge and valley have been cut from rock, and not from drift as above Clifton.

South from Jacobis the valley widens comparatively rapidly, owing to the stream having left the hard Niagara limestone and entered the much more easily eroded Hudson series, consisting of shales and thin bedded limestones. Nowhere below the north margin of the latter foundation was the stream found directly on rock, but everywhere on a mantle of drift which is of variable but usually unknown depth. At Trebines station a few miles west of Xenia a well located 50 yards from the river was sunk to a depth of 49 feet without penetrating rock.

At Alpha the valley expands greatly, though the only tributary there uniting with the Miami is Beaver Creek—a very small stream in a very large valley of which more will be said

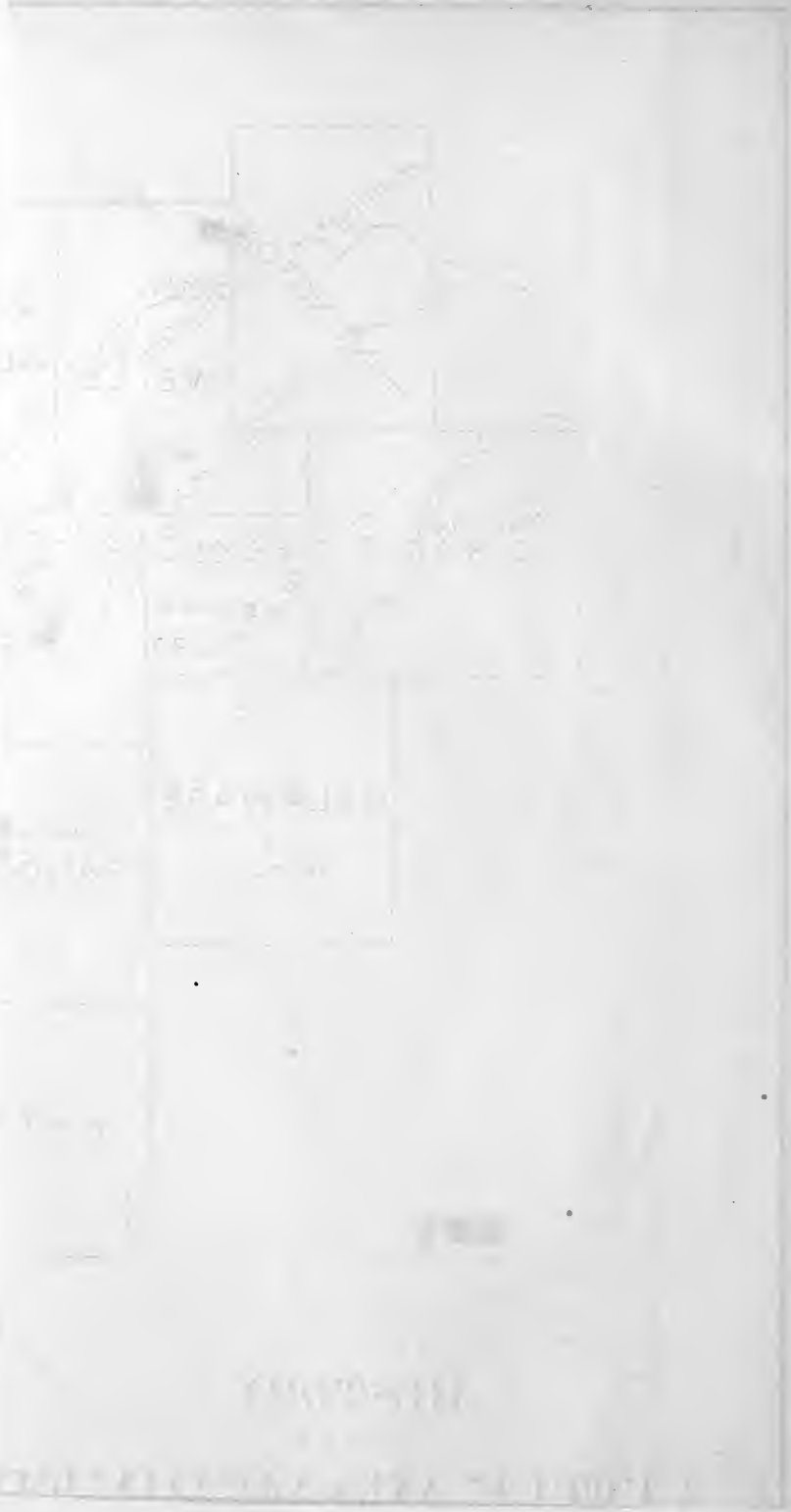

z
ta
LOGAN
Bellefontaine



HISTORY
OF THE
LITTLE MIAMI RIVER
BY
J. A. BOWNOCKER

Drainage in vicinity of Cincinnati after Fowke

LEGEND
Present Drainage ————
Preglacial Drainage - - - - - - -



hereafter. About one mile south of Alpha the valley again contracts, there having a width of perhaps one-tenth of a mile. At this point the valley lies about 75 feet below the top of the bluffs which are steep and composed of rock. Two miles farther down, the valley has again expanded and has a width of one-half mile. From the latter point to Bellbrook there are several variations in the width of the valley. These result largely from the entrance of tributaries and in part from the irregularities in the deposits of drift, and perhaps also from variations in the durability of the rock.

Just east of Bellbrook and north of the point at which the Miami turns abruptly to the east, there is a marked change in the width of the valley. Here the rock bluffs extend so close to the river that the flood plain on one side is only 85 yards wide, while on the opposite side there is scarcely room for a wagon road. A cross section of the valley here is shown in the following figure.

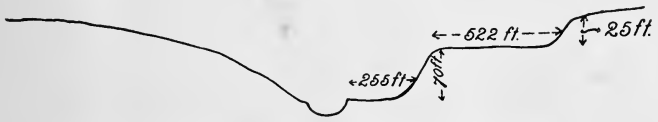


Fig. 1 Cross Section of Miami at Col just above mouth of Sugar Creek

Of special interest is the terrace east of the stream. It is in rock and has a pronounced slope *up* stream. From this point the valley widens, rather slowly up stream and rapidly down. The constriction in the valley and the expansion in both directions, the terrace sloping *up* stream, and the abrupt bend in the river just below, make certain the existence of a col at this place.

At the point where the Miami bends sharply to the east it is joined by Sugar creek which, though the smaller stream, flows through the larger valley. While connecting these two streams one mile north of this place there is an abandoned valley. The following sketch will indicate these relations.

FIG. 2.

Opposite Bellbrook, Sugar creek flows through a valley nearly one-half mile wide. From this place it narrows down stream, reaching the minimum width a few hundred yards before it unites with the Miami. From this point the valley expands rapidly in both directions, and here is located another col. On the east side of this valley is a terrace standing about 70 feet above the creek.

As already stated there is an abandoned valley connecting Sugar creek with the little Miami about one mile north of the point at which the two streams now unite. This abandoned

valley is about one-half mile wide, and so corresponds to the present valley of Sugar Creek at Bellbrook. Similarly it harmonizes with the Miami at the place of junction with that stream. These relations show plainly that Sugar Creek formerly flowed through this old valley, and thence northward in the valley of the present Miami.

The Miami valley below the point of junction with Sugar creek was occupied by a stream which flowed east to Spring Valley where it united with another stream which will be discussed later.

Now the question how was the change from these conditions to the present produced? The answer is not difficult to find. It is one of the many changes produced by the great ice-sheet which formerly covered the northern half of the continent. The existence of a terminal moraine across the valley at Alpha shows that the ice front once stood at that place. This effectually blocked the course of the north flowing Sugar creek. The waters were ponded in front of the ice forming a long and narrow but deep lake. The waters rose higher and higher until they overflowed the divides, thus starting the streams in their present courses. The rapid flowing silt laden waters soon lowered the divides thus draining the lake, but not until its bed had been rapidly silted with drift. After the withdrawal of the glacier the streams found it easier to continue in their new channels than they did to clear out the drift deposits and resume their preglacial courses.

From the point of junction of Sugar creek and the Miami, the latter flows east to Spring Valley and thence making a sharp turn runs due south for a few miles. The valley widens until just opposite Mt. Holly where it is a mile or more in width, not being exceeded in this respect by any part of the valley except just above Cincinnati. Everywhere in this section of the river there is a heavy mantle of drift. About ten years ago a deep well was sunk at Spring Valley, and according to the best evidence now obtainable 170 feet of drift were found. This well it should be noted was on the north side of the valley in the angle made by the sharp bend in the stream. More recently two deep wells

were sunk at Waynesville, but these were at the foot of the hills and only about thirty feet of drift were found.

From the great width opposite Mt. Holly, the valley contracts rapidly to the south. At Waynesville it is only four-tenths of a mile wide, while at Oregonia 6 miles farther down it is less than one-fourth mile in width. The valley continues to contract until a point is reached about three-fourths of a mile south of Ft. Ancient. At this place, locally known as the "Narrows", the bluffs of limestone extend directly down to the river, there being scarcely room for the railroad tracks. No rock, other than drift, was observed in the channel at this point, nor could the depth of drift be ascertained.

Below the "Narrows" the valley widens gradually, but does not become prominent until Morrow is reached. The relations at the "Narrows" indicate the existence of a col at that place. At Morow where the river turns abruptly to the west it receives Todd's Fork, an important tributary from the east, and immediately below the point of junction there is a marked increase in the width of the valley. This sudden change must be due to Todd's Fork; and the wide valley below the place of junction, to the preglacial work of Todd's Fork and not to the much younger stream, the Little Miami.

From Morrow to South Lebanon the valley continues without noted change; but just west of the last named place the river, making a sharp bend, flows due south, and immediately the valley begins to narrow. The change is so rapid that just north of Fosters the valley has become a gorge, there being barely room for the railroad on one side of the river and the public road on the other. After retaining this character for a fraction of a mile the valley widens gradually and continues without abrupt change for a number of miles to the south. Another col exists at the narrows immediately north of Fosters.

Now the question—how shall we interpret the drainage phenomena observed from Spring Valley to Fosters? The answer to this is found in the location of the cols and the character of the valleys. From the col at Ft. Ancient a stream flowed north to Spring Valley where it received an important tributary from the west as already described. From the same col probably a

small stream flowed south uniting at Morrow with Todd's Fork, a much larger stream. It is to the controling influence of the latter that the present Miami makes its abrupt bend at Morrow. From Morrow the preglacial Todd's Fork continued west to South Lebanon in the valley now occupied by the Little Miami. Just west of the last named village a small stream, having its headwaters near Fosters, flowed north and then northwest through the present valley of Muddy creek and soon united with the ancient Todd's Fork, which from South Lebanon flowed northwest through the valley of Turtle creek, and thence into the valley of the present Great Miami at Middletown. From the col at Fosters a stream flowed south through the valley now occupied by the Little Miami.

The change from these early conditions to the present is not difficult to explain. The margin of the ice sheet, known as the early Wisconsin, crossed the old valley just west of South Lebanon and also the valley of the present Miami between Oregonia and Waynesville. This completely blocked the old courses of these streams, and, ponding the waters in front of the ice, formed small lakes. One of these lay between the ice front and the col near Ft. Ancient. Gradually the waters in this small lake rose higher and higher until they crossed the col and started on their southerly course. While this was happening a much larger lake was forming in the Todd's Fork valley. This lake extended from the margin of the ice west of South Lebanon up the valley of Todd'sFork beyond Morrow. These waters rose until they overflowed the col at Fosters which they soon lowered. The level of the waters fell proportionately and soon the lake disappeared, but not until its bed had been much clogged with drift. The thickness of the latter is not known. At King's Mills the shot tower well passed through 62 feet of drift without reaching rock. While this bed was being deposited the floor of the lake near Ft. Ancient was likewise being silted, and the same is true of the old valley west of Lebanon. The clogging of the latter was rendered more complete by the moraine which crosses the valley at that place. When finally the ice withdrew the preglacial courses which were so filled with drift that the streams were compelled to continue in their new channels.

From Fosters south the valley widens fairly regularly to a short distance below Milford. Everywhere the stream flows over drift. At Loveland a well 35 feet deep passed through two thin ledges of limestone, thus showing that the drift at that place is not deep. Below Loveland the quantity of drift increases. At Miamisville the gravel forms a terrace 62 feet high on which the village is located. Just below Camp Denison the Miami has abandoned its old course, and now occupies a channel farther east which is separated from its former valley by a knoll of limestone. Just south of this place is the town Milford, which, in the language of Dr. Orton, "stands on an island of blue limestone" and is surrounded on all sides by deep channels of erosion. The old valley of the river lies to the north and east of the town. These changes may be the result of the heavy deposits of drift which clog the valley in this vicinity.

A mile and one-half south of Milford another marked change occurs in the character of the valley. At that point East Fork of the Miami unites with the river, and immediately there is a decided increase in the width of the Miami valley. East Fork has in places a valley a mile or more in width, and lies 200 feet below the general upland. The valley of the Miami below the mouth of East Fork is comparable with the valley of the latter, but not with the valley of the Miami above the point of junction. These relations indicate that the Miami valley below the place of junction is really a continuation of the valley of East Fork, and that the breadth of the former is really due to the work of East Fork long before the present Miami was born. In those early days a tributary whose headwaters were near Fosters flowed south through the valley of the present Miami, and united with the waters of East Fork where this stream now unites with the Miami.

From this place to the junction with the Ohio the Miami valley is everywhere prominent. At Newton, four miles below Milford, it is more than a mile in width and it is several times wider than the Ohio just below the point of junction of the two rivers. These relations suggest important drainage modifications in the vicinity of Cincinnati, though it is no part of the purpose of this article to discuss these.

Having now traced the several streams from which the Little Miami was formed, and shown in what manner these were united to make the present river, let us consider further those parts of the preglacial streams which are not a part of the Miami. Let us first return to the mouth of Turtle Creek and examine that portion of Todds Fork which lies between the point last named and Middletown. The old valley through which this stream flowed is very conspicuous, and has long been known. It was first mapped by Dr. Orton and published with his article on Warren county in volume three of the Ohio Survey.[1] The width of the valley varies from about a quarter mile to more than a mile, the latter width being found near Middletown. The valley is so flat that the old canal which extended from Middletown to Lebanon was without locks. The depth of drift in the valley is not known. Two wells have been found in which the rock is reported to have been struck at a depth of about twenty feet. This shallow depth may be due to an old island now buried, or more probably to a slab of limestone having been dropped in the old valley by the ice sheet and then covered with drift.

Two or three miles west of the mouth of Turtle Creek a branch valley leaves the main one. This extends north and east passing the city of Lebanon, where two deep wells only a few hundred yards apart showed depths of drift of 126 and 256 feet. Just west of this city the wells which supply the place with water showed only 90 feet of drift, but these were located at the extreme side of the valley. Beyond Lebanon this old valley can be followed to the Little Miami with which it unites a mile or two above Oregonia. The bed of this section of the valley, however, is not flat. There is a rapid rise east from Lebanon to a point about one mile from the Little Miami, where the valley stands 190 feet above the adjacent river and 65 feet below the table-land in which the valley is cut. From this place the valley slopes rapidly to the Miami. The width of the valley at the summit is between an eighth and a quarter mile. Only twice in this tributary valley is rock shown in its bed; once at

[1] Geol. Sur. of Ohio, Vol. III, p. 382.

Lebanon where the course of the stream has been changed by man and only a few hundred feet from where one of the deep wells was sunk; and the other perhaps a half mile from the point at which the valley unites with the Little Miami. This tributary valley may be explained in two ways: (1) It may have been occupied by two streams, one flowing into that part of the ancestral Miami which flowed from Ft. Ancient to the north, and the other to the southwest past Lebanon and thence into the abandoned channel which constituted a part of the preglacial course of Todd's Fork. These streams must have been so situated that their headwaters tapped the divide at the same point, thus producing the present continuous valley. (2) The other method by which this valley may have been formed was by an old stream flowing from the present Little Miami past Lebanon and thence into the main valley farther south. To this theory there are two objections: (1) The stream occupying the adjacent portion of the ancestral Miami flowed north. Under such conditions it is difficult to understand how there could be such a cross stream; (2) the rock in the valley a half mile from the Miami and above the level of the latter is also against this theory.

Caesar's Creek, which unites with the Miami between Oregonia and Waynesville, flows through a narrow valley in its lower course, but two or three miles above its mouth the valley is at least a half mile wide. The divide between this stream and the Miami is everywhere of rock except opposite Mt. Holly where it is very low and composed of drift. In fact this divide is a part of the Wisconsin moraine which skirts the east side of the valley at this place. The gorge-like character of Caeser's Creek near its mouth, the expansion of the valley a few miles up stream, and the low divide composed of drift leads to the conclusion that Caesar's Creek is part of the reversed stream, which once united with the ancestral Miami opposite Mt. Holly. This interpretation it may be added is in harmony with the great width of the Miami at the latter point.

Now the question—what became of that branch of the ancestral Miami which we have traced as far north as Spring Valley? This question cannot be answered as definitely as we might wish. But there seems to be only one course possible

and that was northwest towards Alpha. In any other direction a wall of limestone is encountered. The territory between Spring Valley and Alpha was once the margin of a great ice sheet and when this receded it left a morainic deposit which not only prevented the northward flow of the stream but entirely obscured the old channel. From Alpha its course is plainer, because from that place an old valley a mile wide in places can be readily followed northwest by Osborn where it is crossed by the Mad river, and thence on past New Carlisle to the Great Miami at Tippecanoe. The lower part of this old valley is occupied by a small stream, Beaver Creek, which is insignificant when compared to the valley through which it flows. The other end of the valley is occupied by Honey Creek, likewise a stream which grossly misfits its valley.

At two points only was the depth of drift in this old valley learned. At Osborn there are 207 feet and at New Carlisle 300 feet. Nowhere in the valley was bed rock seen. From these relations it appears not unreasonable to conclude that the old stream which has been traced to Spring Valley continued northwest past Alpha, Osborn and New Carlisle, and reached the valley of the present Great Miami near Tippecanoe. The stream could not have continued north far in this valley, however, for between Troy and Piqua the river flows in a very shallow channel on a bed of limestone. Neither could it have continued west of the Great Miami because there a solid wall of rock is found. To the suggestion that the stream may have turned south at Tippecanoe and flowed through the present valley of the Great Miami there is the objection that the Great Miami itself is regarded by some as a reversed stream. There appears then only one course for it to have taken, that is north along the east side of the Great Miami to just above Piqua where there is a great expansion of the valley and where the drift is more than 124 feet deep. But the old river could not have followed this valley far, because it contracts rapidly and a few miles up stream flows over rock again. About two miles north of Piqua there unites with the Miami, Laramie Creek, a sluggish stream that drains Laramie reservoir situated a few miles to the northwest. This stream everywhere flows over a

mantle of drift and in a deep valley cut out of the same material. The valley is narrow near its outlet but expands up stream, and near the station, Dawson, is fully a half mile wide. A large portion of this valley is undulating, and the irregularities found suggest that it is an old valley filled, rather than a young valley cut out of the drift. It seems to the writer that this valley is preglacial and that the old stream may have flowed through it to the vicinity of Berlin and there have entered the buried channel which has been traced to that place.

The channel to which reference has just been made was studied during the summer of 1898, and the report published in the American Geologist for March of the following year. During the summer of 1899 the work was continued and the mapping of the valley extended. These channels are shown on the map which accompanies this report. As may be there seen, they lie in Champaign, Shelby, Auglaize, Allen and Mercer counties, Ohio, and in Adams, Jay, Blackford and Grant counties, Indiana.

It must be borne in mind that all surface indications of these channels have been destroyed by the great ice invasions. So completely have they been filled that the present streams in places flow at right angles to the preglacial ones. In fact the course of one of the old channels in eastern Shelby county is now the site of a watershed separating the drainage of Lake Erie from that of the Ohio river.

Our knowledge of the location of these channels is due entirely to the driller for oil and gas; and progress in mapping these is likewise dependent upon him. All that we can do is to patiently follow the drill as it moves from section to section, and tabulate the facts which it discloses. Wherever this work ceases there also the work of mapping the old channel discontinues. For the facts relating to the greater portion of these channels reference must be made to the article in the American Geologist already referred to. It is proper here to discuss such additions only as have been made since that article was published.

Work during the past summer has been along two lines: (1) Tracing a tributary of the main channel in Auglaize and

Allen counties; (2) following the channel westward in Indiana. These points will be considered in order. In Washington township, Auglaize county, Ohio, near the Shelby county line, a well in section 23 shows 298 feet of drift; while in section 22 immediately to the west there are 76 feet only. In section 14 due north from 23 a well showed 300 feet of drift without striking rock. The depth of drift outside the channel in this locality cannot be stated since no wells have been drilled there.

In Wapakoneta two wells have been sunk, one on the east side of the city and the other on the west. The former disclosed 125 feet of drift and the latter 90 feet. One mile north of the last well 130 feet are found. One and one-half miles northeast of Wapakoneta in section 16 two wells disclose depths of drift of 398 and 400 feet, with a mile and one-half northwest only 68 feet are found. This shows a drop in the rock floor of 332 feet in the surface distance just given.

The next point at which the channel is struck is in section 34, Duchouquet township. These wells are near the village of Cridersville and just south of the Allen county line. Two wells there disclose depths of drift of 400 and 486 feet; while within a mile either east or west of these the depth is less than 130 feet. From Cridersville the channel runs northeast into Perry township, Allen county. In the northeast corner of section 25 there are 394 feet of drift, while one-fourth mile due south from this there are only 166 feet, and one-half mile northwest only 123 feet. Obviously the channel is here very narrow. To the northeast in section 20 there are 350 feet, but beyond this the drill discloses no marked variations in depth of drift, and so the channel could not be followed farther. The apparent shallowing of this channel to the northeast indicates that the flow of water was to the southwest.

In German township, Allen county, from three to five miles northwest of Lima, several comparatively deep drives are found. In section 15 there are 235 feet; in section 16 there are 262 feet; in section 8 there are 214 feet. But these depths of drift are intermingled with very much shallower ones, so that their interpretation is not easy. Possibly they may result from several deep but very narrow canons.

It may not be improper to say a few words here concerning the continuation of the channel which was mapped last year as far as Anna, Shelby county. Southeast from this village no deep wells have been drilled and so the continuation of the channel cannot be shown with certainty. It may be recalled, however that at the town St. Paris, Champaign county, a drill passed through 530 feet of drift without reaching rock, while east and west of this place the drift is comparatively shallow. The distance of St. Paris from Anna is more than 20 miles and the writer is loth to connect these two points without records at intermediate places. However south from Anna the drift shallows and at Sidney the limestone appears in the river bed. East also from Anna the drift becomes thinner, as is shown by the deep well at Quincy. While these points are not conclusive they indicate that the channel cannot extend either south or east from Anna, while the great depth to the southeast indicates that it extends in that direction and that the channel at St. Paris is a continuation of the one traced as far as Anna.

A few words remain to be said concerning the channel in Indiana. In the report published a year ago, and to which reference has already been made, the channel was traced across Jay and Adams counties into Harrison township, Blackford county. It enters this township in section 20 and passes through sections 26, 35, 34 and 33. The maximum depth of drift reported is 430 feet, while outside the channel the drift is very shallow, not more than 50 feet in places. Near the southwestern corner of this township the channel curves to the northwest and enters Washington township, where depths of drift of 438 and 440 feet were found in sections 20 and 17. Many other deep drives are reported in this locality so that the channel can be definitely located. Continuing in the northwesterly course the channel passes from Blackford county and enters Monroe township, Grant county, where, in the southeast quarter of section 12, 430 feet of drift were found. The channel can be traced through sections 12, 13, 11, 10, 3 and 4 of this township, and then through sections 33, 32, 31 and 30 of Van Buren township, Grant county. In the latter township the depth of drift appears smaller and according to M. W. Page of the Ohio Oil Com-

pany does not exceed 300 feet. From this township the channel enters Washington township and continuing in the northwesterly course can be traced to its center, where in the southeast quarter of section 15, 348 feet of drift are found. Beyond this point the channel cannot be traced at present.

SOME OBSERVATIONS ON THE PREGLACIAL DRAINAGE OF WAYNE AND ADJACENT COUNTIES.

By J. H. Todd, M. D.

In presenting this paper to the Academy I simply wish to lay before you—for your criticism—the results of careful observations on the present drainage system of Wayne and associate counties, together with the relation it sustains to pre-glacial channels, and to a topography modified by glacial forces.

The associate counties are Medina, Ashland, Richland, Knox and Holmes; but even parts of these (with all of Holmes) must be excluded from any associate activity in the *initial* forces that determined the pre-glacial drainage lines. Although later, and before the glacier's advent, they became potent factors in establishing an outlet for the waters, their hills were not in existence when the first lines of drainage were cut; and these first lines are still marked features in our landscape.

These counties rest on the Waverly capping of the northeast face, or incline, of that island or low mountain chain known as the "Cincinnati Arch." Here the arch, owing to its hood of hard Waverly, is least eroded; and, although in Kentucky it presents in intaglio, and at Cincinnati only in slight relief, here the Waverly stands out in bold headlands forming a crescent of highest hills in the State, which decline rapidly to the bed of Lake Erie, and show the original topography, scarred by the original drainage lines.

In studying the Waverly group of rocks in this part of the Island, I find that they dip away rapidly on the west to the oil regions, and on the north under the bed of Lake Erie, while on the east they decline more gradually into the synclinal trough of the Allegheny coal basin; thus constituting a water-shed in three directions. Prof. Newberry says (Vol. I Geological Survey) "It will be noticed that the direction of the drainage streams, which follow the strike of the strata on either side, indicates that it once formed a water-shed that gave the initial bearing to their flow."


MAP AND SCALE
OF
PRESENT AND PREC
DRAINAGE
OF
WAYNE AND ASSOCIATE
IN OHI
Compiled from field notes &
by
J.H. TODD
HURON
SPEARS
Milan
NORWALK
EAST TOWNSEND
Harland
Pontiac
OLENA
Stuben
New Fairfield
New Haven
Plymouth
Shiloh
Richland
London
544 AL
Shelly
544 AL
Ontario
Spring Mills
Crestline
LEXINGTON
BELLVILLE
Jeromeville
Williamsport
Pulaskville
Mansfield

MAP AND SCALE
OF
PRESENT AND PREGLACIAL DRAINAGE
of
WAYNE AND ASSOCIATE COUNTYS
IN OHIO
Compiled from field notes & drawn
by
J.H. TODD
PRESENT DRAINAGE
PRECLACIAL DRAINAGE
GLACIAL COLS
LINE OF HIGH ELEVATIONS
INCOMPLETE DATA
WRIGHT'S GLACIAL LINE
LEGEND
WHAT THE GLACIER DID FOR OHIO
CLEVELAND
ERIE SHALE
BLACK RIVER
WAVERLY
ELYRIA
VERMILLION RIVER
CONGLOMERATE
MEDINA
COAL
ASHLAND
WAYNE
WOOSTER
STARK Co
RICHLAND
HOLMES
KNOX
MANSFIELD

Any one walking as I have walked, from Wooster by Hayesville and Mansfield to Bellville; and then crossing the profile from Ashland to Loudonville: will see this fact demonstrated to convicition.

In the first tramp (Wooster to Belleville) you cross all the streams that drain the eastern face of the plateau; and the elevations, as determined by barometer, may be instructive. Wooster University stands 522 feet above Lake Erie. Killbuck Valley 332, Jefferson, on rock summitt of plateau, 600, the flood plain of Muddy Fork 432, and the divide between this and the Jerome Fork 650, while its flood plain is 450. Hayesville, on the summit of the divide between the Jerome and the Black Forks, 700, and the flood plain of the Black Fork at Mifflin is 500, the depot at Mansfield 581, and the plateau south of the city is 800, and above Bellville 900. In the cross section from Ashland to Loudonville the divide between the Jerome and the Black Forks, independent of glacial deposits, is almost a level plane, with only a gradual descent of rock strata of about 50 feet.

The valleys in which the streams run average about three-fourths of a mile, and the rock floor averages about 150 feet below the present bed of the streams, while the rivulets and creeks that form the streams, start from the rock with the dip of the rock, and only mar the strike of the strata by erosion as they proceed.

The above presents a picture of the extreme eastern face of the plateau, showing the uniformity of elevations between streams, and the gentle dip of the plateau to the north and east, as well as the depth to which it was eroded by pre-glacial streams. Prof. Newberry further says: "A current from the south swept the eastern shore of our ancient Atlantis that floated the trunks of tree-ferns and branches of lepidodendron to Sandusky." This *current* gave the *initial* direction to a pre-glacial stream that, in after time, carried the waters not only of the Waverly but of the virgin coal hills as well, to the great channel through the bed of Lake Erie.

The crescent of the highest hills spoken of, that bound the elevations, and head the present streams, presents one horn resting on Medina county, the other on Knox, while the center

includes the Savannah Lakes in Ashland county. It forms the rim of a bowl or hydrographic basin, and its pinnacles of highest hills show as the zig-zag wanderings of a worm fence.

The rivulets and creeks dovetail and intertwine like the locking of fingers; while all along the crest are to be found, between the exposures of native rock, the remains of old lakes, gravel knolls, cat swamps, sink holes, and millions of boulders, the largest two lying near Lodi and Ashland, with an estimated weight of 300 and 350 tons respectively.

The elevations of this rim above Lake Erie are, Wadsworth 700 feet. But Wadsworth is underlaid with coal, and is therefore east of our pre-glacial channel, *which must run exactly between the Coal Measure hills and the Waverly capped Island.*

Seville is on carboniferous conglomerate, and is situated west of the valley of the river Styx, which drains the coal fields north and west of Wadsworth. It is just on the edge of the Coal Measures, and its elevation is 403 feet above Lake Erie, while drillings in the vicinity show 300 feet of drift. This makes a rapid decline of near 600 feet in six miles to the rock bottom of the Seville valley, and the surface decline continues west into a broad valley, where we are justified in assuming the same amount of drift with a lower well head, although no drillings have been made in the center of the valley.

On the west side of this valley $1\frac{1}{2}$ miles east of Leroy, and southwest of Chippewa Lake, a drilled well shows 149 feet to rock, and going north east to a point $4\frac{1}{2}$ miles due south of Medina village, and northeast of Chippewa Lake, a drill was sunk 190 feet and no rock was struck, but $\frac{1}{4}$ miles north, *Waverly* rock was struck at 125 feet. While $1\frac{1}{4}$ miles south, rock was struck in Carboniferous conglomerate at 42 feet, showing a northeast channel through Chippewa Lake on the edge of the conglomerate.

Following this line to a well three miles due east of Medina, near the head of Rocky river, I find 140 feet of blue clay above 60 feet of white sand; the well was abandoned at 200 feet without reaching rock, as sand ran up the pipe to water level. This well head is 180 feet below Medina and it makes the bottom of this drill hole 133 feet above Lake Erie.

This is not conclusive, but it shows no rock bottom at a level lower than Wooster and Orrville, and provides an outlet for the waters of Wayne county to Rocky river, and thence to the lake *between the Coal Measures and the Waverly.*

Ascending from this well to Medina village the elevation is 513 feet above Lake Erie, and crossing the divide between Rocky and Black rivers I find the surface elevation at Lodi to be only 282 feet; thence up to West Salem the register gives 575; at Polk 640; above Ashland 650; at Savannah lakes 700; north of Mansfield 862; and by the registered grades of 892, 912, 932 and 952 I am on the Belleville hills, and ascending to the south of Independence I find myself on one of the highest pinnacles in the State, about 1000 feet above Lake Erie.

Note the graded ascent of the crest that divides the waters, or rather note the descent, and remember that this decline in elevation means the gradual dip of a plateau, the face of which presents north and east.

The streams that drain this basin all trend east or southeast, toward one central axis, and this axis was primarily Prof. Newberry's current from the south that swept around this headland to Sandusky; and next, during the putting down of the Coals, the forecasts of these channels supplied fresh water to the coal marshes in the Allegheny basin: and lastly, after the Coal Measures were elevated to their present level, the axis channel became the trough to carry the waters from both the Coal and Waverly hills to the great pre-glacial river that ran through what is now the basin of Lake Erie.

This large hydrographic basin is now made up of six smaller ones; the Clear Fork, Rocky Fork, Black Fork, Jerome Fork, and Muddy Fork, of the Mohecan river; and the mysterious basin of Killbuck from Wooster to Burbank, where a glacial dam breaks its association with Black river, and fills a scallop or "Water-wier" in the Waverly, below the present surface of Lake Erie. These streams all run in broad valleys, with flood plains near a mile wide; they are separated by high table lands which showed—before the glacier's advent—evenly bedded rock strata, but now they are crushed like a ship in arctic ice. The bed and trend of these streams conspire to impress you—not

so much with their individuality—as that they are parts of a whole, converging to a common axis of drainage, and this axis is the trough between the Coal hills and the Waverly from Loudonville to Lake Erie. The P. F. W. & C. R. R. follows this trough from Loudonville to Wooster, and its record of levels will tell us the grade of descent. Mansfield is 578 feet above the Lake, Lucas 518, Perrysville 433, Loudonville 412, Lakeville 378, Shreve 352 and Wooster 342 above Lake Erie, making a decline of 236 feet between Mansfield and Wooster or about 6 feet to the mile.

This old waterway is clearly defined from Loudonville to Wooster, and from there is easily traced by Orrville and Chippewa Lake to Rocky river; that portion between Loudonville and Wooster is bounded by high and rocky hills of Waverly on the northwest, and Carboniferous conglomerate on the southeast; and the channel ran the entire distance, exactly between these too widely different geologic formations. It is filled to varying depths with gravel, and sand, and clay; its surface presenting a broad and fertile valley, with soft undulations between kames, kettle holes, and cranberry marshes.

Its rock floor, however, is of greater interest to the student of preglacial water ways, and, beginning at Loudonville, a drilled well shows this rock floor to be 150 feet below the village, making our starting point 262 feet above Lake Erie. Next, near the bridge over Lake Fork, where a preglacial channel comes in from Mohecanville, the rock floor is determined by the chain of lakelets that marks its course; their depth being about 130 feet, and the surface elevation here being 375 feet gives the rock bottom 245 feet above Lake Erie. Applying the same rule at Odel's Lake, through which the axial channel passes, I find rock at 228 feet; and at Big Prairie with a surface elevation of 390 feet, a drilled well shows 176 feet of drift, making the floor 214 feet above Lake Erie.

Near Alligewi (Custaloga) Junction between Big Prairie and Shreve, where the precursor of the Lake Fork, that tore out a channel 10 miles long, 1½ miles wide and 400 feet deep—counting from hill tops—thus creating the "Big Meadow" of the Indian and the "Big Prairie" of the Pioneer, entered the axial channel by

Brown's Lake, the surface is very deceiving. The drift seems piled in without order—now rising into hills 500 feet above the lake, and resembling a divide, and now sinking to the plains of the prairie—but a well was drilled here on the plane, at the Brown farm, to water at 170 feet—no rock encountered—and as the well head's elevation was 380 feet, it shows the rock floor to be less than 210 feet above Lake Erie.

Two miles from this, at Shreve, the elevation is 352 feet, and many wells have been driven to water—the only object sought—which is found in white sand under blue clay at from 60 to 105 feet. So I am safe in assuming the rock floor to be less than 200 feet, as the continuance of a channel is unquestioned.

Still, if the channel at Shreve should be regarded as a tributary from the coal hills of Holmes county—and here such a preglacial channel does come in—it would not modify the facts given above, nor embarrass my water-way to Wooster, as there is another way for the waters to proceed. A channel which was possibly used during the later history of the coal beds, when changes of level were common, and shiftings of coal into Waverly, and Waverly back into coal, were frequent, is traceable west of the Shreve hills—in which is found a small pocket of No. 7 coal—and it returns to the axial channel through the preglacial channel at Millbrook.

A very little digging would now turn the Lake Fork into Killbuck. So little that the A. & W. R. R. were afraid to run their track from the clay plant in the Big Prairie to Millbrook through this valley, for their engineer assured them that their track would be flooded if they cut half a mile through the gravel barrier that divides the Big Prairie from the Millbrook valley, as the flood plain of Big Prairie is 150 feet above that of Killbuck. This channel will be more fully studied in the future.

On the Troutman farm, near Millbrook, and where the above old channel comes in, a well was drilled on a gravel knoll elevated 376 feet, to the depth of 185 feet, but no rock struck; four furlongs east on the Webb farm, a well was driven to water at 100 feet and no rock encountered; while two furlongs a little south of east, and one furlong from the hill, rock was struck at

40 feet. These drillings were all on Sec. 6, Franklin township, Wayne county.

It would seem that between Shreve and Wooster, where the widening channel from Millersburgh enters the axial channel, the rock floor has been deepened as well as widened and a preglacial lake, tripod in shape, formed.

The spread of the rugged inclosing hills, the great flood plane known to the pioneers as the Killbuck swamps, and which to them became a lake at each "spring flood", all go to prove this. The basin would be 10 miles long from Wooster to Shreve and 8 toward Millersburgh, with a width of from $1\frac{1}{2}$ to 3 miles; over this plane the Killbuck Creek then crept from hill to hill, and back again like the doublings of a snake. The Indian chief, Killbuck, made himself noted by killing a deer with an arrow from his bow that, on its errand of death, crossed the creek three times.

One drilling in the center of this lake, $1\frac{1}{2}$ miles south of Wooster, and 5 miles from the cross section wells, with a well head of 330 feet, shows 185 feet to rock and 480 feet to Berea sand (which here has a thickness of 27 feet); this makes the rock bed of the channel only 145 feet above Lake Erie, and to this must all other levels conform, unless the lake character of a basin with a deeper bottom than the main channel can be proved. This brings me to the city of Wooster, and from here to Orrville I have a rough road to travel, but the preglacial water came here, and there was but one way for it to go out, and I must find that way *under* the high gravel hills between here and Orrville. On the south of Wooster is Madison Hill, on which is located the Ohio Experiment Station, with its quarry of elegant Coal Measure sandstone; and $1\frac{3}{4}$ miles north of it across Apple Creek valley, on a terrace of which is located South and East Wooster, Wooster University is planted on a hill of naked Waverly shale 522 feet above Lake Erie. Madison Hill has about the same elevation, and between them, but near 200 feet below them, sparkles the crystal water of Apple Creek. No drillings have been made in the center of the channel to the rock floor—so its elevation cannot be proven here—but many drillings have been made for water, which is found in white sand

at from 95 to 105 feet. One well was drilled to rock on the side of the channel, at the foot of College Hill and showed 120 feet to shale; while six furlongs east, across the Apple Creek, at the foot of Madison Hill, rock was found at 45 feet and the channel runs between these two wells.

From this throat at Wooster the axial channel proceeds almost due east for a distance of 8 miles to a point 2½ miles southwest of Orrville, near which the C. A. & C. R. R. enters and follows it in a northeast direction to Orrville. It is bounded by the same type of Coal Measure hills on the southeast, and Waverly on the northwest as at Wooster, but the trough is filled with drumlins of varying heights. At Honeytown, three miles east of Wooster, the Apple Creek enters it through a preglacial channel from the coal hills on the southeast; but it is so deflected by glacial *debris* that it turns on itself and follows the axial channel back to Wooster and thence to the Killbuck.

Near Honeytown I can give you a better record of rock floor; one-half mile east of that hamlet on the Mock farm—Sec 7, East Union Tp.—a well was drilled to the depth of 185 feet and no rock found. The well head has an elevation of 345 feet and shows the rock floor to be, at most, less than 160 feet above Lake Erie. In the N. E. ¼ Sec. 2, East Union Tp., two and one-fourth miles southwest of Orrville, near the C. A. & C. R. R., a well was drilled through sand, gravel, and yellow clay, above 50 feet of blue clay, soft as mud, and the well was abandoned as hopeless in this "blue soap" at 110 feet, without striking rock, while one-half mile away in the S. E. ¼ of same Sec. hard sand rock was struck at 3 feet, but drilling was continued in the rock until at the depth of 50 feet a flowing well was struck which yields ten gallons of pure water per minute. This well was on the side of the channel. This would seem to throw a little light on the origin of the many flowing wells about Apple Creek, Shreve, Fredericksburgh, and along some of the preglacial waterways of Ashland county.

But I leave this in the satisfaction I feel in being able to demonstrate a deep preglacial channel under these hills that connects the axial channel with the broad valley of swamps that lie north and east of Orrville where it is joined by the out-

put of the dismal swamps bordering Newman's Creek, which seems to open—as a wedge—the coal measure hills of Baughman Tp. to drain them.

Of course I cannot demonstrate the elevations of the rock floor to these mysterious swamps, for no drillings have been made in these marshes to their bottom, that I am apprised of; but no geologist who has examined them has ever doubted the existence of a preglacial channel here. His only question has been, "To where does it go?" And I think I can prove to you, at least by circumstantial evidence, that the channel proceeds through these swamps north, and after taking in the waters of the Red Run region, goes northwest diagonally across Milton Tp. south of Sterling and east of Creston, where, after reversing or rather doing away with the necessity of a Chippewa Creek, it took up the waters of Killbuck's head from Wayne Tp. and carried them to Chippewa Lake to be forwarded to Rocky River.

One proof of this is found in the fact that two and one-half miles southeast of Sterling, in Milton Tp., an Artesian well, in the line of the channel, has for thirty years filled a three inch pipe with pure water from a depth of 80 feet, and no rock was encountered in its drilling. And second, when the A. & G. W. R. R. was building from Sterling to Creston, some fifty years ago, a section of the track sank out of sight, went down in the night to stay, and they had to change the line and use the wood from an acre of heavy oak timber to steady it in the new place. The third item of proof is that several wells have been sunk in the line of the channel east of Creston to 160 feet and no rock struck. These wells are in valleys some 50 feet lower than Creston village, as I am informed. I am also informed by a prominenet member of the U. S. Geological Survey that "a well at Sterling has about 400 feet of drift." I have been unable to locate this well unless it be one situated about one mile northwest of Sterling, near the Medina county line, which reveals great depth of drift, but the exact thickness I could not secure. Yet enough was secured to demonstrate a rock floor very nearly on a level with the surface of Lake Erie, or about the same elevation, as I will show in the Black River

channel, only 10 miles west, over the horse-back divide at Lodi.

Such a channel in width and depth, *could not have been produced by drainage from the north,* for, it is only 12 miles to the rock crest above Medina city, and but six miles to the north and south divide between Chatham and Lafayette townships.

It was on the foot hills of the east face of this divide that the two wells —noted in the early part of this paper—were drilled to rock, at the respective depths of 149 and 125 feet; they are $4\frac{3}{4}$ miles apart, and, joining them with the Medina city foot hill, $4\frac{1}{4}$ miles north, they mark the eastern extension of the Waverly as a surface rock, from Le Roy to Medina, a distance of nine miles. Opposed to this headland of Waverly I find the declining face of the last projection of the Coal Measures from Sharon to Seville, where the quarries of Carboniferous conglomerate are worked from the western face of the hill, and it was between these diverse and opposing faces that the primitive channel ran into that of Rocky river.

I must now search for a cause of sufficient magnitude to convert the drainage system described, into that of the present; a conversion that has created a new topography for a large part of the State of Ohio.

When the glacier passed from the soft shale bed it had plowed out for Lake Erie to lie in, it met two mountainous obstacles of greater, and yet unequal resistance; viz: the Coal Measure hills and the Waverly plateau, each still rising to the height of 700 feet, with the pre-glacial channel, over which now runs the Rocky river exactly between them; seven miles east of Rocky river, opened the wide mouth of the Cuyahoga, that drained the northwest face of the Coal Measures: a cross section of these, from east to west, through the center of Cuyahoga county shows (according to Prof. Newberry in Vol. I, Geological Survey) the pre-glacial bed of Rocky river to be 3 miles wide and that of the Cuyahoga $4\frac{1}{2}$ miles, with the intervening Coal Measure projection only 7 miles. Now 14 miles west of Rocky river comes down across the Waverly the broad trough over which now flows Black river, and all these wide pre-glacial channels worn down into the Erie shale, below the Lake's present

level, making three broad and deep breaches between the prime obstacles barring the glacier's even progress. Huge as it was its course was modified.

Striae on the hills of Summit county are directed *southwest,* while on the pure Waverly of Richland and Ashland counties they are *southeast;* these scorings if *projected* would meet in the Killbuck valley. How could such scorings be produced? Is it not plain to anyone with operative intelligence, and a mind unbiased by pre-conceptions, that the broad inclined plane from Mansfield to Wooster, facing the high range of hills bordering the Tuscarawas valley from Massillon to Akron, would of necessity influence the ice-front, when a lower plane was there, and lead you to expect and search for just such glacial scratchings? Here were two forces acting the one against the other, and together they directed a lob of the glacier that had entered the inviting depression created by the three open channels across Cuyahoga ,eastern Lorain, western Summit, Medina and Wayne counties until it was stranded as a bow on the hard high hills of Holmes county, just before it reached the continental divide of the Coal Measures; this bow a little more than subtends the south front of Wayne county, the bowstring being about 30 miles long, while the central projection is about 8 miles to Millersburg, with the Killbuck valley as a fixed arrow in the bent bow,

This lobe of the glacier seems to have become detached from the main body just where the Coal Measures end below Loudonville in Ashland county, for the main mountain of ice slid on south over the smoother face of the Waverly that skirts the Coal Measures to below Newark, before it was deflected—a distance of 40 miles. Now, it was this arrested lobe of the glacier, that brought the load of material that changed the entire topography of the hydroghaphic basin described in this paper; from Cleveland to Millersburg, and from Massillon to Mansfield, its burden of *Life in Death* was put down, giving a new physiognomy and a new physiology to the landscape; and the remodeled features, with their fresh expressions, made the face of this valley a thing a beauty to the eye and a blessing to the nation; the angular hills and gorge-like valleys, were rounded

up into gentle swells, and smoothed out into graceful undulations, and the food in the "glacier's grist" was so digested and assimilated that hill and dale rejoiced in verdure unsurpassed, and there was left as our inheritance, as fine a grazing and wheat-growing section as the sun shines on.

But our old water-ways were obliterated, filled with drift to hundreds of feet above their holding, and new drainage channels must be created; a few of which, together with their mode of creation I will attempt to describe. The Clear Fork of the Mohecan, followed, in part, the old channel to near Perrysville, but was here obstructed in its course to the Black Fork gorge by drift; the obliterated channel being now distinguished by two small lakes—or kettle holes between the high gravel knolls that turned the waters. The deflected stream then cut a new channel southeast to the Mohecan, its newness being demonstrated by numerous falls, the most picturesque being Lyons Falls, where the stream cuts down into the crumbling red sandstone of the Waverly immediately below the Carboniferous conglomerate of an outlying coal hill, revealing many and beautiful casts of fossil. The Black Fork was blocked by morainic material where the Killbuck lobe of the glacier became fixed on the Loudonville hills; but it found a col a mile below the village, where the diverted Clear Fork rejoined it, and, uniting their forces they cut a narrow gorge through hills that now stand 425 feet above the rock bottomed and rock banked Mohecan. Here a mountain of sand stone and shale is cut in two as you would cut a loaf of bread. The next col is at Lake Fork where, because their old channel in the Big Prairie was walled up by a glacial dam now 180 feet high, the Muddy and Jerome Forks of the Mohecan were compelled to mingle their waters and tear down a low breach in the hills at Fort Tyler into a gorge 200 feet deep, and 3 miles long, through a divide, to gain—at Rochester a pre-glacial channel coming down from Mohecanville.

This channel of waters—now called Lake Fork—followed to above Lakeville, where they were again staggered out of their course by the hill like obstructions of glacial debris that here stopped transit in the axial trough, and, they must a second time cut a way through high conglomerate hills for 7 miles to join

the new channel of the united Black and Clear Forks, 5 miles below Loudonville, and create the Big Mohecan.

We now come to the mysterious Killbuck, the preglacial heralds of which entered the axial channel at Wooster, but its mystery is explained by the lately discovered fact, that it was not through its *entire course* that it so entered pre-glacial times—even from the north,— and its channel from the south will be discussed later.

Late investigation has developed a new feature in the Killbuck and Black river valleys, one that throws much light on the enigma of pre-glacial drainage in this region, and these newly observed facts make it necessary that I repeat a few salient points of my paper, and introduce additional detail.

I must especially recall to your mind the picture of an island in a Devonian sea; and this island made up of a fold of Silurian and Devonian rock, capped with deeply eroded Waverly. The head of this island was near the mouth of the Black river trough that drained this face of the Waverly; and its sides are now practically bounded by an imaginary line running through Norwalk, New Haven, Galion and Mt. Gilead—on the west, and on the southeast and northeast, by the Coal Measure conglomerate from Independence, by Loudonville, Wooster, Orrville and Rocky river from head to mouth.

It must be remembered that this island has never been entirely submerged since the elevation of the Waverly. Its surface constituted a plateau with only rounded and eroded edges, as determined by the strike of the strata, while the waters drained from it—owing to difference in *temperature* and *quality*—assisted greatly in developing into *permanancy* a current along its sides —from south to north—and around its head. This current was maintained during the putting down of the Coals and *instituted* the axial channel for all pre-glacial drainage in this region. On the west and north we had the progenitors of the Huron, Vermillion, Black and Rocky rivers; on the southeast and east we had the *initial* channels of the Clear, Rocky, Black, Jerome and Muddy Forks of the Mohecan river, and a portion of Killbuck channel, pouring their floods into this common current; and this, through all Carboniferous and subsequent time, until the gla-

cier's burden blocked the way. What a game of shuttle-cock must have been played between the *debris* of their floods, and the deposits in the coal marshes, from the frequent oscillations of land and sea during this æon of time; and how this shifting of *debris* and growth must have modified the course of the current at different times! And when we think of the corrosive influence of the atmosphere, and the erosiv power of the streams, we will not wonder at the great width and depth of the main drainage troughs noted above, nor at the occasional dove-tailings of the Waverly and the Coal Measures conglomerate that throws a shadow over the course of the mutual outlet for their waters.

Furthermore, not only was this water way obscured, but the entire face of the plateau was transmuted. Erosion had so marred its features, and glacial drift so deformed them, that my first examination was faulty and I must add to, and explain, the elevations noted in the early part of the paper. The line of highest hills there noted marks the present divide between Lake Erie and the Ohio river, but not the pre-glacial divide marking the crest of the Waverly. I found it to be south, and east of this line of hills. Entering Wayne county south of West Salem, it passes across Congress township about two miles south of Congress village, and crosses the Killbuck one mile north of Cedar Valley (now Overton) and entering Wayne township it intersects a north and south divide from Burbank to Wooster in such a manner as to almost present the picture of a turkey's foot, the central toe—the continuance of the continental divide—extending across Wayne township to Green and ending at Smithville. The right toe, being represented by a range of hills that run southeast to Wooster, where Wooster University is located on the extreme front, 172 feet above the city's square. From these two points the descent of the Waverly is very rapid until it disappears under the Coal Measures. The elevations of these spurs are, above Wooster 640 feet, above Smithville 700 feet, and the rock is badly crushed. The projection of the third toe is disgramed by a line of high elevations running from the heel at Cedar Valley, northeast across Canaan township, and almost paralleling the middle division of Killbuck valley—to

east of Burbank—where it was connected with the divide separating the Black from the Rocky river, and shows that a north and south pre-glacial divide in the plateau did exist from Medina to Wooster; and where it was crossed by the continental divide above Cedar valley, the Killbuck gorge was bisected.

Here the hills banking the Killbuck are less than 80 rods apart, although nearly 200 feet high, and the stream runs on a rock bottom.

From this point, and from all the northeast face of Congress Tp. the collected waters were carried into one channel, that of the Black River, at Lodi, and thence to the Lake. Drilled wells west of Burbank show 100 feet to rock; in the Harrisville swamps 90 feet, and its bottom is studded with innumerable boulders. Southwest of Lodi rock is found at 120 feet, and two miles northwest of Lodi on the Little Black River, the drill passed through 285 feet of drift before reaching rock, and the well head is 45 feet below Lodi; two miles north of this, where the valley is 20 feet lower, no rock was struck at 270 feet, and one mile northeast rock was not reached at 217 feet, but $1\frac{1}{4}$ miles east of the line of these wells, with well heads 45 feet above Lodi, rock was reached at from 200 to 204 feet and the ascent is very rapid from here to the crest of the divide between Black and Rocky Rivers, which follows the line between Chatham and Lafayette townships. Many other wells have been drilled in this region of which I have the records, but these are enough to show that the preglacial trough over which the Black River now winds its torturous course was many feet lower than the present level of Lake Erie. The next observation of interest made here is connected with the unique Killbuck, which now drains the northeast angle formed by the crossing of the divides near Cedar Valley.

Bisecting this angle was found a preglacial channel passing northeast through the Jackson swamp to join the axial channel near Creston. The three heads of the present Killbuck, after uniting, follow in part this old channel across Canaan Tp. to its northeast corner and there, turning abruptly west, the stream cuts its way for seven miles through the divide to the trough of Black River, where it again turns at an acute angle and pro-

ceeds southeast to Wooster, passing, after traveling 24 miles, within one mile of the springs that mark its head.

The explanation is this: When the great mass of morainic material which formed the hills between Creston and Sterling was piled into, and over the water-way, then as low as the Lake's present level, of course this channel was obliterated, as well as the one coming from Canaan Tp., now represented by the head of Killbuck. The dammed up waters of the Killbuck channel formed a lake at Jackson, and the obstructed waters in the axial channel created the larger lake from Orrville to Easton. Now these lakes must have an outlet, and the waters of the eastern one, now represented by Orrville swamps, Chippewa Creek, and the subterranean passage near Sterling, where fish came up when the railroad went down, cut its way by a low col in the coal measures at Warwick and gave birth to the Tuscarawas River.

The other, or Old Hickory Lake, forced a way directly across the north and south divide, creating a broad and rocky channel for Killbuck to Burbank, but the Black River trough was also blocked by a series of kames running east and west and forming the south border of a Lake imprisoned between Burbank and Lodi, now known as the Harrisville Swamp. So the Killbuck waters must search for a new way out, and being joined by the embarrassed waters of the northeast face of Congress Tp. enough force was generated to cut a narrow path through the continental divide near Cedar Valley, and so the Killbuck river was completed and sent on its way to join the Tuscarawas at Coshocton.

This completes the preglacial and present drainage of the northwest half of the hydrographic basin. The southeast half shows a rim made up of hills as high, and hard, and irregular, as those on the west and north, but of different material. The first were of Waverly, while these are composed of all the factors of the coal measures. Each of the seven numbers of the coals are represented, while limestone, and sandstone, iron ore, and chert are found as capstones to the rim of the bowl through all of Holmes county. The line of the divide starts near Independence and Bellville in Richland county, and passes through

the southwest corner of Hanover Tp, Ashland county, touching the northeast corner of Knox county, and crosses the Mohican four miles south of its junction with the Clear Fork and near its union with the Lake Fork. From here it runs northeast into Knox Tp., Holmes county, and crossing an enigmatical north and south divide that turns Black Creek to the east, it continues in a northeast direction across the township and enters Monroe Tp. at its northwest corner, then bending southeast it traverses the township nearly midway between Paint Valley and Welcome, and has for its crest the Blue Stone, of which the Millersburgh court house is built, and the red sandstone known as Killbuck red sand-stone. From here, after crossing the southwest corner of Hardy Tp. it enters the north corner of Killbuck Tp. and crossing the Killbuck River 4 miles below Millersburg, locates a narrowing in the Killbuck channel, supposed to be a col, just where that stream turns to the southwest to be joined to the Black Creek. From here this divide enters in an easterly direction the northwest corner of Mechanic Tp. and crosses the township in zigzags until it approaches the northeast corner where it turns abruptly northeast to Santillo P. O., then east through a stone-quarry region and on to a point two miles south of Berlin, where it again turns northeast and passes north of New Carlisle, where a new turn directs it to the limestone ridge above Weinsburgh. It here leaves the county of Holmes in worm-fence progression, possibly to Dundee, or in some other way to assimilate with the confining walls of the mysterious Tuscarawas.

I have not had the privilege of tracing it, nor determining the location of the col in the Big Sugar Creek, whence the waters were carried in preglacial times from the Newmans Creek channel north of Orrville.

But this I have determined, that a spur of the divide passes from near Weinsburgh by Mt. Eaton to Kidron, inclosing a territory that sent its waters to Kidron, and thence to the Apple Creek channel. Along this old water way, Artesian wells are secured from white sand at from 75 to 80 feet. This valley is followed by the new Camp Railroad from Kidron to Honeytown. It is no easy matter to determine the exact crest of the

divide, but the character and quality of the earth together with the strike of the rock strata, determines the trend of the rivulets that make up the creeks, and the creeks continue in the same general course until a ravine has been reached cutting into strata of lower geologic formation; here a new direction may be given, which is again modified by elevation and strike of strata. Unlike Wayne county, the strike of the strata in Holmes county is very irregular. We used all these points in following the line of divide, spending five days between Loudonville, Nashville, Napoleon, Oxford, Millersburgh and Holmesville, and the prime thing noticed, as obscuring the investigation, was the influence of the *glacial moraine* on the direction of the rivulets. The morainic material from Stark to Ashland county is abundant on an irregular line from two to four miles north of the crest of highest hills and gradually thins out to the crest, creating an intervening *border plain* where the rivulets seem to struggle to find a way out, and then,shuddering back, make crow-feet markings on the summit, or they huddle together, forming little pools, or they spread out to form peat swamps, like the notable one north of Berlin where the Ohio Ground Sloth (Megalonis Jeffersonii) was found.

Any one will recognize these important facts who will critically examine the line of the terminal moraine as platted by Prof. G. F. Wright.

I say important because they must be used in questionable cases, as the Sugar Creek and upper Tuscarawas regions.

This brings me to the preglacial channels that drained the Carboniferous side of the completed hydrographic basin and were tributary to the common water way. The first on the west was a small channel coming in just south of Loudonville and one mile north of the present confluence of the Clear and Black forks; it drained the higher hills of Hanover township and is crossed by the new bed of the Clear Fork. Drakes Valley from Nashville to Lakeville marks the line of the second.

The third in order drained the limestone highlands of Ripley and enters the main channel just west of Shreve. A well on the D. E. Foltz farm shows 91 feet to water but no rock. We are now at the south exposure of the Limestone ridge of

Ripley township and all its waters were directed by the dip of the rock to the Paint Valley channel, which started near Nashville and enters the Killbuck channel near Holmesville.

The next and principal tributary is the great Killbuck channel, in which the waters are now reversed. We located the col in this river 4 miles south of Millersburgh, but later observations reveal many facts pointing out Oxford as the site of the col, and that the Black Creek gorge sent its waters to Wooster. In driving from Nashville to Napoleon by a route west of the common, I found a range of hills starting from the east and west divide in Knox township that had not been considered in the first investigation, and although this discovery does not do away with the significance of the line of high hills there noted yet it does constrain me to believe that this divide was surrounded by a range of higher hills, and that the waters of Black Creek were included by them. This line continues almost parallel with the Mohican River to old Fort Fizzle, west of Napoleon, and from here is directed to the "Summit Ridge" in Richland township, and only separated from it by a strait so narrow that it seemed like a col. As the summit ridge is continuous to Oxford and forms the dividing ridge between Wolf Creek and Black Creek; and also because there is a line of high hills on the south side of Killbuck Valley that connects with, and is continuous with the line of hills in Killbuck township where I located the col, I fear that the former location of the col only noted the crossing of a line of hills, and that the true col was at Oxford. But leaving this for future investigation, when I will note the observations by barometer, I return to the sixth channel, a small one that comes in, between coal hills, two miles south of Millersburg from a fissure directed to Berlin. The eighth comes in from Salt Creek township, between Holmesville and the Holmes county infirmary. It is now occupied in part by Martins Creek. A drilled well here shows 196 feet to rock. The eighth in order is probably of more importance to the people of Wayne county than all the others combined, for it furnishes a series of flowing wells of the purest water. It drained a large portion of Salt Creek and Paint Creek townships in both Wayne and Holmes counties. I have only traced

the channel a short distance into Holmes county, where it is now represented by Dry Run, passing down a fissure between coal hills southwest of the south branch of Salt Creek, and entering the Big Salt Creek valley near the tile factory below Fredericksburgh; here it is joined by a small channel from the limestone hills of Wayne county. At this point is located the col in the Big Salt Creek, and from here the stream goes tearing over a rocky bed and between rock hills to Holmesville five miles distant. From this col the old channel passes almost due north to old Edinburgh, where it is joined by the preglacial channel coming in from Kidron by Apple Creek. It then proceeds in a northwest direction along the valley of the Apple Creek to Honeytown where it enters the main channel to the lake by Orrville.

This valley is one-half mile wide and is filled with drift from Honeytown to Fredericksburgh and Kidron, and flowing wells are secured on every farm in its course, except near Honeytown where the dam in the great channel is complete. The obstructing glacial hills rise to 200 feet above the plane and no rock is found below the flood plane at 185 feet, and Apple Creek is turned, like the Killbuck at Burbank, almost at right angles back to Wooster. In all the flowing wells water is found on blue boulder clay and in white sand. Fredericksburgh wells are about 100 feet deep, Apple Creek 120 and rock is reached at Apple Creek at 186 feet.

This completes the description of the channels tributary to the central channel, as far as the one represented by the Big Sugar Creek. And here I must call your attention to a feature in the location of these channels which will be better understood by referring to the map accompanying this paper, viz., all the channels that enter the axial channel from the coal measures enter it through fissures or gorges between coal hills; and this fact must help us in determining the original course of the channels now occupied by Sugar Creek, Newmans Creek, and Chippewa Creek; the waters now in them trend out, but we think this evidence shows that in preglacial times they flowed in.

First, as to Sugar Creek, in which the col is not located, it will be observed that it now passes up a ravine, between coal

hills, from a point in the axial channel that is more than 110 feet below its present bed; and second, that the rivulets from the innumerable springs that line its border, through all of Sugar Creek township to Stark county, have their primal direction with the strike of the strata, which is contrary to the present course of the stream.

Now the law of the other channels and coal hill fissures being applied to this would show the stream to be reversed. Nearly the same features with the same expressions are found in Newmans Creek for six miles across Baughman township, with this addition, the old dismal swamp of which this stream is the remains was shaped like an Indian arrow head, the point driven into the coal hills as far as the Stark County line, and along its sides coal banks facing each other, and all entered by drifts. The shoulders of the dart on the north and south are represented by short preglacial channels entering from the hills, while the stem is pictured by the mouth of the swamp as it entered the Orrville glacial lake. There is neither coal nor conglomerate under the swamp, but its margin is marked all around by conglomerate, and the environing hills are coal from the base of the dart to its point. The mines on its opposite sides, across the shaft of the arrow, are but half a mile apart, while at the barbs the hills are two miles apart, and the stem at its neck is half a mile broad, but it widens to near three miles where it enters the lake. It seems plain that this dismal swamp or "Shades of Death," as the pioneers called it, marked the line of a preglacial channel tending north and west.

The direction of the next preglacial channel was northwest from the coal hills to the axial channel, and is now indicated by Patton Lake, Fox Lake and Red Run, all located end to end in the Tamarack swamp, which is a marsh on the side of a hill.

The next channel, that through which the Chippewa Creek now flows to form the head of the Tuscarawas River, is from a scientific point of view the most important of all, for it has of late been a mooted question where the Chippewa Lake and the Sterling channels sent their waters in preglacial times.

The old supposition was that they went out by the Chippewa Creek channel to the Tuscarawas and thence to the Ohio River. But a later conception sent them by Warwick and New Portage to the Cuyahoga River and thence to the great Lake Erie channel, but in both of these the reckoning was made without considering the existence of the axial channel described, or the force of the Orrville Lake.

My first objection to them is that I have found another way through which the waters could proceed, and that the Chippewa channel passes over Carboniferous conglomerate that was once covered with coal. In other words, it shows a breach in coal hills that is not consistent with their formation, but which is in accordance with the idea presented above, that the dammed up waters of the Orrville Lake selected the point of least resistance to force their way through their prison walls, viz., the V-shaped fissure still recognizable in the coal hills on the sides of this channel. In sections 26 and 25 of Chippewa township coal mines are operated less than a mile apart with the Chippewa Creek channel between them, making the strait too narrow for the volume of water to pass. It would be like passing a two-inch ball through an inch augur-hole. But as it is not the outlet we are contending for, but only for the general trend of the main channel between the Waverly and Carboniferous, and its tributaries from the hills of widely separated geologic periods. I will wait for further developments before I will change my present thinking, that these waters went from the Orrville Lake across the Chippewa channel, receiving it as a tributary from section 26, through Chippewa Lake to Rocky River and thence to the great preglacial channel in Lake Erie.

PREGLACIAL DRAINAGE CONDITIONS IN THE VICINITY OF CINCINNATI.

By Gerard Fowke.

At the winter meeting of the Ohio Academy of Science, in 1897, I offered a paper upon the above subject. This was published as a Bulletin of the Scientific Laboratories of Denison University, in volume XI. Recently the opportunity has been afforded by the Academy, through the McMillan fund, for further exploration of the region. Some discoveries resulted which considerably modify so much of that article as relates to the section below Cincinnati.

In order that the reader may arrive at a correct understanding of the matter herein presented, it will be necessary to utilize such portions of the report already published as refer to the territory east of the Great Miami river, and acknowledgment is hereby made to the Denison University for permission so to do.

The initial point of this part of the Ohio was near Manchester, at the col (A). A few miles below, Cabin creek entered, and at Maysville it was joined by Limestone creek. For distinction, the name of the latter is given to the stream. At short intervals below, other tributaries put in, each marked by a large area of bottom land. Between them the valley is somewhat narrower. This is because gravels and silt cover the low points at the junction of the streams, where the combined valleys are widest. These features continue to the mouth of the Little Miami. The distance between the hills bordering this tributary is very much greater than the width of the main valley at any place above; and the shrunken stream which winds its devious way from side to side of the included level, seems entirely inadequate to the task of carving out such a basin. Immediately below this, at Dayton, Kentucky, opposite the upper end of Cincinnati, the Ohio contracts almost at once to a narrow channel, very much less than that of the Little Miami. It is evident that a col (B) at this point formerly deflected the waters of old Limestone to the northward. On passing through this gap, the Ohio

LEGEND

COLS (LE

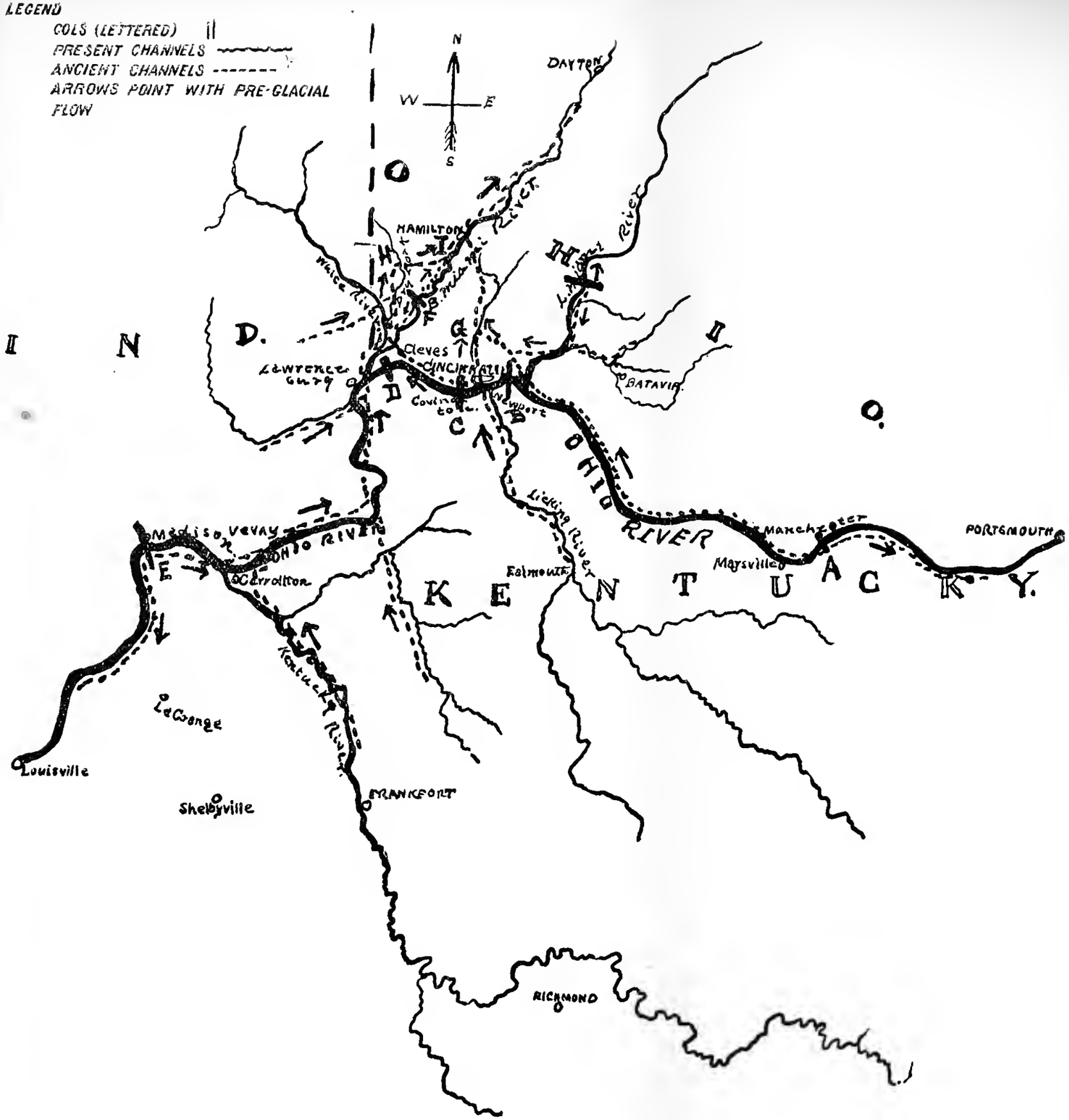
PRESENT

ANCIENT

ARROWS

FLOW

II


LEGEND
COLS (LETTERED)
PRESENT CHANNELS
ANCIENT CHANNELS
ARROWS POINT WITH PRE-GLACIAL FLOW
N
W
E
S
DAYTON
HAMILTON
Miami River
Miami River
Miami River
Whitewater River
Whitewater River
I N D.
O.
Cleves
CINCINNATI
Lawrenceburg
Covington
Newport
BATAVIA
OHIO RIVER
Madison
Vevay
OHIO RIVER
Carrollton
Licking River
Maysville
PORTSMOUTH
Ashland
Elsmere
K E N T U C K Y.
Kentucky River
LaGrange
Louisville
Shelbyville
FRANKFORT
RICHMOND

is seen to flow between extensive bottom lands on which stand the cities of Cincinnati, Newport and Covington. Here it receives the Licking from the south and Mill creek from the north; the latter, like the Little Miami, coming through a valley in which it seems almost lost as it meanders aimlessly back and forth. Then the Ohio passes into a very diminished space at Sedamsville, where it flows on rock bottom. This is the site of another col (C); and from here the hills gradually recede to North Bend. Three miles below North Bend was another col (D); a little farther down the Ohio suddenly debouches into a very broad valley where it receives the Great Miami. Like the two streams observed above here, the latter seems utterly incompetent to the excavation of the trough which it occupies.

This valley holds its width to the mouth of the Kentucky, varying somewhat from the average in different parts, as it does elsewhere. One noticeable feature along this stretch is that nearly all the tributary streams have a direction opposite the current of the river; that is, in going down the main stream one is looking toward the sources of those which flow into it. There are also several abrupt bends; in these the outer side of the curve is at the foot of the steep hills or cliffs, while on the other side are wide bottom lands. At Sugar creek the river makes an acute turn to the west, which course it holds past Carrollton, where it receives the Kentucky. From this town it rapidly narrows until it reaches Madison (E). Here was the last col above Louisville. The valley contracts until on the Indiana side the water washes the solid rock, while on the Kentucky side there is a strip of level land only wide enough to afford room for a single warehouse.

Two miles below Madison, the river turns again toward the south through a gorge which gradually expands until it opens into the basin in which Louisville is situated.

The interpretation of these facts is about as follows:

When old Limestone was deflected northward by the col at (B) it entered the depression lying north and east of Cincinnati. Here it received a considerable tributary from the east by way of the present East Fork. The united streams flowed west, and reached Mill creek valley at the point (G) in the vicin-

ity of Carthage. A short ravine joined them, from the hills where the Little Miami discharges, but that river was not then in existence, being a post-glacial stream.

It will be perceived that when old Limestone turned northward, it was separated from the Licking only by the col at (B). Between this col and the one at Sedamsville (C) the Licking flowed north into Mill creek valley where it continued its northerly course. Receiving old Limestone at (G) it passed on and entered the valley of the Great Miami at Hamilton.

From the west side of the col at (C) a ravine extended to North Bend. The hill behind this village, though apparently continuous with the blue limestone formations on either side, is composed of glacial material. This fact was first disclosed when the railroad which passes through here undertook to make a tunnel; it was found that the limestone was absent. Consequently only a cut was needed. This cut is in the lowest part of the deposit; the higher hills to the eastward are also composed of drift. This proves that the ravine from (C) formerly turned to the north at this point, reached the Great Miami valley at Cleves, and there turned west along the present course of the river.

The wide valley below the col (D) has an interesting history. It is continuous from Hamilton to the mouth of the Kentucky river. This fact, in connection with the rapid narrowing of the Ohio between Carrolton and Madison, together with the certain evidence of a col at the latter place, proves beyond question that this ancient bed was eroded by the Kentucky river. In other words, that stream, instead of following the present Ohio as it does now, or flowing across Indiana, turned to the east and north to join the Licking at Hamilton. There is no other channel through which it could have gone. The hills in every other direction, except at the gorge below Madison, are unbroken. From Lawrenceburg it extended almost due north through the valley now partially occupied by the Whitewater and Dry Run, to the point (H). Here it turned east, and at (I) reached the Great Miami, following that valley to Hamilton. From Hamilton northward the old river bed is filled with drift and has not been traced. There can be no doubt, however,

that it joined old Kanawha north of Dayton—probably in the neighborhood of Piqua.

The lower part of the Great Miami requires a few words of explanation. There was a col at (F), just south of the village of Miami. North of this Taylor's creek flowed north and emptied into the Kentucky at (I). South of the col (F), a small ravine joined the creek that flowed through the gap at North Bend, at a point somewhere near Valley Junction (K).

Having thus traced the former rivers and their tributaries, and located the cols, so far as they are essential to the problem, we are in a position to follow the steps by which the Ohio was established.

The Great Kanawha held its way across Ohio until the glacier had advanced to that part of its valley which extended farthest to the northward. For a time the waters may have skirted the ice-front and recovered their natural channel farther down; but presently the valley was completely closed and the imprisoned waters found no escape until they had reached the level of the col at Madison (E).

At this stage began the readjustment of drainage channels. The principal stream at this time was, of course, the Kanawha. How far it may have extended toward the north or the northwest, we have no means of knowing; but it was probably first reached by the glacier at some place west of Ohio. Shut off by this agent from its natural outlet, it turned back into the old Kentucky, wherever their confluence may have been; followed that channel past Hamilton, Lawrenceburg and Carrolton and was impounded by the col at Madison (E). If we may judge from the nearly uniform level of the hills on either side of the river there, up to the very edge of the cliffs which descend steeply to the water, this point in the old watershed was but little lower than any other along the crest. Whatever its elevation, the Kanawha was compelled to rise to its level. As a result, a lake was formed which reached well up toward the headwaters of every stream between the Kentucky river and the Cumberland mountains on the south and to the eastern part of Ohio on the north. It had to reach the level not of the bottom of the gap, but of the highest flood of the torrents which poured

through the gap. The mythical "Lake Ohio," which is currently believed to have resulted from a blocking of the Ohio river by the glacier, would be insignificant by comparison—admitting, for the sake of comparison, that it ever existed as so frequently described. The area of the real lake, created by the Madison dam, can be ascertained only by carrying the level at which it stood at its outlet, up the Kentucky, Great Miami, Licking, Big Sandy, Kanawha, and across central Ohio toward the headwaters of the Tuscarawas. Until this level is ascertained we cannot know how much of the country was submerged, or how many of the existing high areas were drowned. Neither have we any means at present of knowing how long these conditions prevailed. They may have lasted until the col had worn low enough to drain off most of the accumulated water. On the other hand, the advancing ice may have pushed this water in front of it, and maintained a constantly diminishing lake until its most southern limit was reached. If we may suppose the former supposition to be the correct one, then a new river was established; following the Kanawha as far as the mouth of the Licking-Kentucky, and that stream, reversed, from there toward the south and west.

In time, the encroaching ice covered the site of its junction with these two rivers, and Kanawha was again deprived of an outlet. A second lake was formed, including the basin of the Kanawha and all its tributaries east of the Licking. It increased in area and depth until it surmounted the col at (A); flowing over this divide, its waters would follow old Limestone to its junction with the Licking at the point (G), thence north to Hamilton, and so find their way to the Kentucky.

The glacier reached Hamilton, and for the third time a lake was formed. Both Kanawha and Licking were now shut off; the water rose over the col at (C). The Kanawha reached this by following old Limestone as before to (G), and thence down the Mill creek valley. Pushing through the gap at North Bend, and past Cleves, they reached the Kentucky along the bed now occupied by the Great Miami below that village.

When the ice came to the hills about Cincinnati, the mouth of old Limestone at (G) was obliterated, and for the fourth time

Kanawha was backed up into a lake which rose until it overflowed the col at (B). Joining Licking again, the two followed their last channel as far as North Bend and probably out past Cleves; but there is a possibility that before the col at (B) was removed the ice had advanced far enough to reach the hill below North Bend and obstruct that outlet. In this case the new lake would have included Licking as well as Kanawha, and had to rise to the level of the col at (D) before it could have begun to drain off. If, however, the col at (B) was worn down in time for the water above it to escape past Cleves, then, when the ice had advanced across the valley below Cleves, a fifth lake covered the upper Ohio valley before the col at (D) was eroded and the present drainage to the mouth of the Great Miami establishd. It is possible there was still a sixth lake, though if so it was of less extent and shorter duration than any of the others, and was due to a projection or loop of the glacier pushing out of Miami valley as a dam to the new Ohio—which name is now applicable to the river for the first time—until its waters broke through a ravine back of Petersburg, Kentucky. The depression thus formed is usually spoken of as "an abandoned channel of the Ohio," but it was occupied only while torrents from melting ice were far above existing flood plains. It furnishes about the only evidence, by the way, that the glacier ever reached the Kentucky hills.

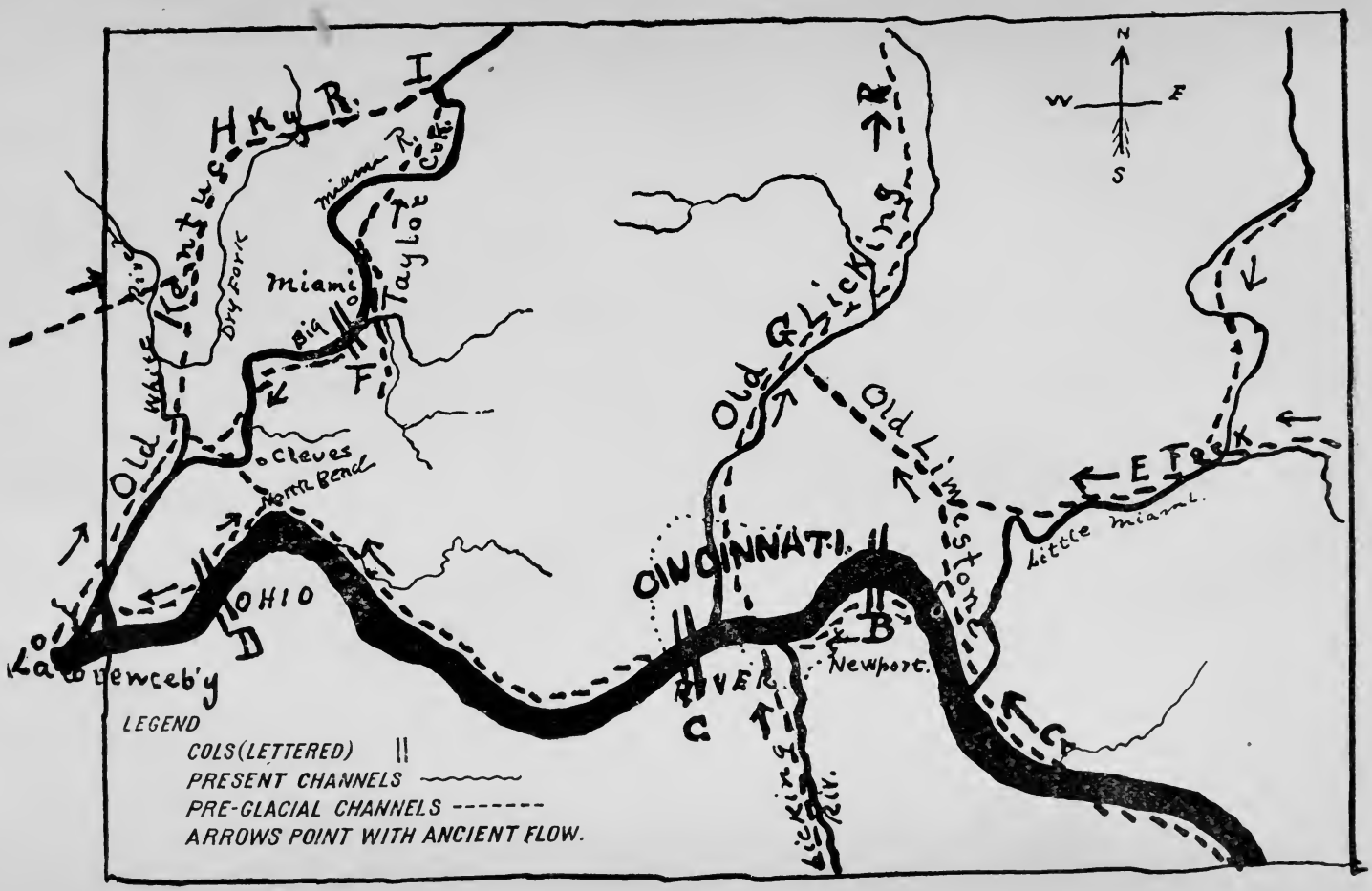
The theory advanced here in regard to the succession of glacial lakes is based entirely on the assumption that the col at Madison (E) was broken down sufficiently to drain the first one formed, and upon the further assumption that the ice reached each necessary point for the formation of a lake, in the order here given. There seems to be no doubt regarding the first and most extensive one; the existence of the others depends upon the strength of the col at (E) and the relative periods of time at which the subsidiary streams were blocked. It is not necessary to presume a constant forward motion of the glacier; its advance may have been frequently interrupted, or there may even have been an occasional recession without in the least invalidating the argument. The effect would be the same in the end, whether there was a continuous progressive motion, or

an intermittent action. Even if there was more than one glacial period, the sequence of events would not be greatly different from the series here described. The work was begun by the one which first blocked the Kanawha, and was completed by the one which extended farthest south.

When the ice retreated, the drift which it left behind shut the rivers and creeks off from their former ways, and they were left as we now find them. The channel of old Limestone has been partially taken possession of by the Little Miami and its East Fork; the part between these streams and its former mouth at (G) is deserted. Licking turns west at Covington, and its ancient valley from Cincinnati to Hamilton has been pre-empted by the insignificant Mill creek. The Whitewater, a post-glacial stream, and the mouth of the Great Miami use a fragment of the old Kentucky river valley in Ohio, but the part between (I) and (H) is abandoned. The Miami utilizes that portion of its channel between Hamilton and the point (I), where Taylor's creek formerly emptied; but the immense gravel deposits which were left here deflected the new river toward the east. It followed a small ravine for a short distance, then broke over a low place in the divide between this ravine and Taylor's creek, filled the latter to the col (F), tore this out, and at Cleves fell into the creek which came through the hill at North Bend; it went with that creek to the drift filled valley of the old Kentucky near Valley Junction, through which it has eroded its devious way to the Ohio.

A large creek entered the old Kentucky at the town of Harrison; the Whitewater crossed this to reach the ancient valley, leaving an island of Silurian rock between the former and recent beds, just as the Great Miami did at the gravel deposits at (I).

The old streams herein described flowed through valleys which were eroded to a considerable depth below the waters which now go through them. While the new channels were forming the old ones were being filled with sediments of mud-laden torrents and debris from masses of floating ice. The streams of today have not had time to clear out these deposits, so they remain as the bottom lands on either side of


N
W
E
S
Old Kentucky R.
Dry Fork
Miami R.
Miami
Big Bend
Taylor
Old Licking R.
Old Limestone
E Fork
Little Miami
Cleves
North Bend
OHIO
CINCINNATI
Newport
RIVER
Licking Riv.
LEGEND
COLS (LETTERED)
PRESENT CHANNELS
PRE-GLACIAL CHANNELS
ARROWS POINT WITH ANCIENT FLOW.

the river. As such they must continue to exist until a greater elevation above sea level of the interior region permits the Ohio and Mississippi to scour their channels deeper than the present grade lines will allow them to do.

The extensive drift deposits south of Cincinnati have not yet been accounted for in a satisfactory manner. Professor Wright says that the great masses of conglomerate two miles below Aurora, Indiana, are the terminal moraine. Only a casual inspection is needed to show that this assertion is entirely unfounded. There are similar deposits farther down, and at a much greater altitude, which he has overlooked, or at least not mentioned. A careful examination of this entire territory is required in order to determine the limit of the ice sheet; to ascertain what part it may have taken in the surface changes below Lawrenceburg to estimate the relative elevation of the hills at Madison and those where these deposits are found; and to discover the probable causes which led to the gravel deposits upon the high lands in Boone county, Kentucky.